INSTALLATION

PERFORMANCE WORK SPECIFICATION

FOR THE MCM1 CLASS
MAIN PROPULSION & GENERATOR
DIESEL ENGINE REPLACEMENT

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American National Standard Letter Symbols for Units of Measurement	**ANSI/IEEE 260.1**
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Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24	**ASME B16.5**
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Standard Test Method for Surface Burning Characteristics of Building Materials	**ASTM E84**
Standard Specification for Valve Locking Devices R (2001)	**ASTM F993**
Xylene (Ten-Degree Grade)	**BSMI K1009300**
Electric Plant Installation Standard Methods	**DOD-STD-2003**
Development of Shipboard Industrial Test Procedures	**DOD-STD-2106**
Magnetic Silencing Requirements for the Construction of Nonmagnetic Ships and Craft (Metric)	**DOD-STD-2143**
Colors Used in Government Procurement	**FED-STD-595**
Trials and Inspections of Surface Ships	**INSURVINST 4730.1**
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Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment	**MIL-STD-740-2**
Thermal Insulation Requirements for Machinery and Piping	**MIL-STD-769**
Schedule of Piping, Valves, Fittings, and Associated Piping Components for Naval Surface Ships	**MIL-STD-777**
Nondestructive Testing, Welding, Quality Control, Material Control and Identification and Hi-Shock Test Requirements for Piping System Components for Naval Shipboard Use	**MIL-STD-798**
Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety	**MIL-STD-1310**
Human Engineering	**MIL-STD-1472**
Noise Limits	**MIL-STD-1474**
Bending of Pipe or Tube for Ship Piping Systems	**MIL-STD-1627**
Tube, Copper-Nickel Alloy, Seamless and Welded	**MIL-T-16420**
Terminal Boxes, Connection, for Electrical and Electronic Systems, General Specification for	**MIL-T-24558**
Cable, Navy, Insulation Resistance	**MS-18297**
Relief Valve Operating Characteristics Versus Maximum Operating Pressure for Liquid Service	**MS-18282**

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Rubber, Fluorocarbon Elastomer, High Temperature, Fluid and Compression Set Resistant	**SAE AMS-3216**
Insulation Sleeving, Electrical, Heat Shrinkable	**SAE AMS-I-23053/2**

STANDARD DRAWINGS

Air Conditioning, Ventilation and Heating Design Criteria Manual for MCM	
Ventilation Standard Access Plates	**501-1131916**
Project Peculiar Document	**802-6336069**
Project Peculiar Document	**802-6336823**
Handwheels for Valves	**803-1385620**
Spray Shields FDR Mech Joints	**803-2145518**
Hanger Pipe Design, Installation and Arrangements	**803-5001054**
Packings & Gaskets Application Criteria for	**803-B-153**
Hangers, Pipe, for Surface Ships	**804-1385781**
Ventilation Closure Watertight and Fire-Resistant Model "R" Round	**804-1749102**
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Insulation, Passive Fire Protection-Installation Details	**804-5184182**
Acoustic & Thermal Insulation for Compartments	**804-5773931**
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Round Access Cover for Nwt Duct 6 Dia Quick Opening Type Assembly	**805-1363772**
Round Access Cover for Nwt Duct 6 8 & 12 Dia Quick Opening Type Details & List of Matl	**805-1363775**
Cover, Access, Round-AQ-NT-DUCT	**805-1363776**
Thermal Insulations for Compartments Installation Details	**805-1749057**
Hull Type Drawing, Inclined Ladders Steel Assemblies & Details	**101-860039**
Hull Type Drawing, Inclined Ladders Steel Assemblies & Detail	**101-860040**
Vanes, Channels, Ventilation Vane	**S3801-385260**

DISTRIBUTIVE SYSTEM TECHNICAL MANUALS

Piping Systems Brazed, Fabrication And Inspection	**0900-LP-001-7000**
Navy Resilient Handbook	**0900-LP-089-5010**
Ship Construction Tests & Trials	**0900-LP-095-2010**
Strainer Fuel & Lube Oil Safety Shield Design, TM W/CHG 1 & 2	**0948-LP-102-2010**
Noise Isolation Pipe Hanger Design Handbook	**0948-LP-063-9010**
Piping Devices, Flexible Hose Assemblies, TM Volume 1	**S6430-AE-TED-010**
Expanded Ship Work Breakdown Structure for All Ship and Ship Combat Systems, Vol I.	**S9040-AA-IDX-010/SWBS 5D**
Expanded Ship Work Breakdown Structure for All Ship and Ship Combat Systems, Vol II.	**S9040-AA-IDX-020/SWBS 5D**
Requirements for Fabrication Welding and Inspection and Casting Inspection and Repair for Machinery, Piping and Pressure Vessels	**S9074-AR-GIB-010/278**
Welding And Brazing Procedure And Performance Qualification /248	**S9074-AQ-GIB-010/278**
Lubricating Oils Greases Specialty Lubricants and Lubrication Systems, Ch. 262	**S9086-H7-STM-010**
Electric Plant General, Ch. 300	**S9086-KC-STM-000**
Piping Systems, Ch. 505	**S9086-RK-STM-010**
Compressed Air Plants and Systems, Ch. 551	**S9086-SY-STM-010**
Preservation of Ships in Service, Ch. 631	**S9086-VD-STM-000**
Nonmagnetic AC Generator (Ship Service Diesel), 375 kW, 450 volt, 601 amp, 1800 RPM, 3-phase, 60 Hz	**S9311-CF-MMO-010**
General Specifications for Overhaul of Surface Ships (GSO)	**S9AAO-AB-GOS-010**

REPORTS

David Taylor Model Basin (DTMB) Report No. 880	**DTIC No. AD 224812**

INSTRUCTIONS

Table of Acronyms

BERP	Bolted Equipment Removal Plates
cfm	cubic feet per minute
cmm	cubic meters per minute
CRES	Corrosion Resistant Steel
gpm	gallons per minute
HVAC	Heating, Ventilation, and Air Conditioning
lpm	liters per minute
NDT	Non-Destructive Test
rms	root-mean-square
rpm	revolutions per minute

1.0 SCOPE

1.1 <u>Scope</u>. This specification establishes the installation requirements for interfacing the ship's distributive systems to the four new Main Propulsion Diesel Engines (MPDE) and three new Ship Service Diesel Generator Engines (SSDG) on MCM-1 class ships. The new engine specifications and performance data are specified in the document titled "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships". Unless otherwise specified, each section of this document shall describe removal boundaries, system function and performance that apply to all seven diesel engine installations. The four MPDEs and one SSDG are located in the Main Machinery Room, (3-63-0-E). Two SSDGs are located in the Auxiliary Machinery Room (3-41-0-E).

2.0 REQUIREMENTS

2.1 <u>General</u>. Before beginning any work, all engine electrical systems shall be de-energized and tagged out of service according to ship's procedures. All engine-piping systems shall be de-pressurized and isolated to prevent sudden pressurization or discharge that would endanger personnel or damage equipment. Lifting padeye capacities shall not be exceeded. All system fluids shall be drained from each engine and each system secured and prepared for Mid-Term, Lay-up (1-16 weeks) Per NAVSEA S9AAO-AB-GOS-010.

2.1.1 Removal. Disconnect all electrical and mechanical systems connected to each engine to the boundary limits specified in each system section. Remove each engine and deliver to the local item manager for disposition. All removed components shall be stored in such a manner as to allow use on other hulls still using such equipment.

2.1.2 Interferences. Piping and equipment removed as interference to allow removal of existing diesel engines and installation of new diesel engines shall be removed and installed as follows:

a) Interferences not requiring modification shall be reinstalled per requirements of ship as built system drawings.
b) Interferences requiring modification shall be reinstalled using materials meeting the requirements of system installation drawings. Drawings shall be prepared documenting final installation per the requirements of Section 3.085.

2.1.3 New Interface Components. All new interface components shall meet the design limits of the specific system they become a part of, while meeting the provisions of the new engine. The new diesel engines shall replace the existing engines for both applications (MCM MPDE and SSDG). All interfacing systems shall perform as described through this document and shall not adversely affect existing system components or degrade the system reliability and maintainability. The new engines for both applications shall be of the same family of engines to maximize maintainability and interface design.

2.1.4 Design Guidance. The individual Ship Builder's Design Specification shall be used where distributive system design information is desired and no other document or drawing exists with more current information. Section 3.0 of this document has been numbered to match expanded ship work breakdown structure (ESWBS) numbering.

2.2 <u>Performance Summary Values</u>. The following section summarizes the interface information from Section 3.0 for the MPDE and SSDG. For more detailed information, see appropriate sections in 3.0. The engine manufacturer shall verify that the information summarized here and expounded in each section is within the range of the engine performance requirements.

3.0 SYSTEM INTERFACE AND PERFORMANCE

3.051 <u>Ship's Characteristics</u>

3.051.1 General Requirements. The installation of new diesel engines and their distributive systems shall not reduce the ship's capacity or performance capabilities as described in paragraph 3.051.2 below.

3.051.2 Stability Reconfiguration Limits. New system installations shall not change the condition of the ship's stability (see Section 3.096).

3.051.3 Magnetic Signature Controls. All metallic material (except material required to be magnetic due to its function and authorized by NAVSEA) shall have a magnetic permeability of 2.0 or less after fabrication. All non-magnetic, electrically conductive, continuous loops of installed piping, with conductivity 10% of International Annealed Copper Standards (IACS), shall not enclose an area exceeding 7 yd^2 (6 m^2) without an electrical isolating fitting. Consult DOD-STD-2143 for actual limitations on continuous piping runs if the enclosed area exceeds 7 yd^2 (6 m^2), or material conductivity is less than or greater than 10% of the International Annealed Copper Standard (IACS).

3.051.4 Stowage. The installation of the engine shall not cause an increase to stowage or stowed equipment on board the ship.

3.070 <u>General Requirements for Design and Construction</u>

3.070.1 Environmental Conditions.

3.070.1.1 Service Operation during Ship Motion in a Seaway. The diesel engine mounting system and all miscellaneous foundations wherever necessary shall be designed to withstand dynamic forces produced by motion of the ship in a seaway under the following conditions:

a) Loads Due to Ship Motion – Ship motion shall be assumed to give the loading factors specified herein. These factors include gravity components as well as inertia effects. To obtain forces, the factors shall be multiplied by the weight of the structure, stowed equipment or material. Factors apply to actual weights only, not to specific design loads, such as hydrostatic loads and deck live loads. It shall be assumed that any combination of forces in the three directions may occur simultaneously.
b) Storm Conditions – For structure that is expected to carry working loads during rough weather, the following loading factors apply:
   1. Longitudinal: 0.39 plus 0.012 for each 10 feet (above or below the center of gravity.
   2. Transverse: 0.57 plus 0.042 for each 10 feet (3 meters) forward or aft of the longitudinal center of gravity, plus 0.12 for each 10 feet (3 meters) above or below the vertical center of gravity.
   3. Vertical: 1.0 (plus or minus 0.5) plus 0.21 for each 10 feet (3 meters) port or starboard of centerline, plus 0.09 for happened each 10 feet (3 meters) forward or aft of the longitudinal center of gravity.

c) Moderate Sea Conditions – For structure that is not expected to carry working loads during rough weather, the following loading factors apply:
   1. Vertical: 1.0 plus or minus (.25 plus 0.10 for each 10 feet (3 meters) port or starboard of centerline, plus 0.05 for each 10 feet (3 meters) forward or aft of the longitudinal center of gravity.

3.070.1.2 Equipment and machinery shall operate satisfactorily, maintain satisfactory lubrication, and without loss of oil from machinery or hydraulic systems, under the following conditions:

a) When the ship is permanently trimmed down by the bow or stern as much as 5 degrees from the normal horizontal plane.
b) When the ship is permanently listed up to 15 degrees to either side of the vertical.
c) When the ship is pitching 10 degrees up or down from its normal horizontal plane.
d) When the ship is rolling up to 45 degrees to either side of the vertical.

3.070.2 Operational Conditions. The new diesel engines shall be capable of withstanding emergency and training scenarios as described in the Engineering Operational Sequencing System (EOSS) and Engineering Operational Casualty Control (EOCC) and operational procedures for selected support systems.

3.070.2 Flooding Water Level 1 (FWL-1). Flooding Water Level 1 is defined as the highest level that can be expected on any particular intact main transverse watertight bulkhead when that bulkhead serves as a confining boundary to flooding that the ship is expected to be capable of surviving. Flooding water levels (V lines) on main watertight bulkheads and over the bulkhead deck are as follows:

a) Frame 14: 4.36 feet (133 cm) below 01-level, 4.44 feet (135 cm) on 01-level.
b) Frame 28: 2.44 feet (74.4 cm) below 01-level, 4.59 feet (140 cm) on 01-level.
c) Frame 41: 4.37 feet (133 cm) below 01-level, 8.22 feet (251 cm) on 01-level.
d) Frame 63: 5.50 feet (168 cm) below 01-level, 10.34 feet (315 cm) on 01-level.
e) Frame 86: 3.20 feet (97.5 cm) above main deck, 28 degrees angle to horizontal
f) Frame 99: 3.72 feet (113 cm) above main deck, 28 degrees angle to horizontal.
g) Frame 107: 1.30 feet (39.6 cm) above main deck, 29 degrees angle to horizontal.

3.071 <u>Access</u>

3.071.1 General Requirements. The engine and generator rooms have a system of grating walkways for personnel movement throughout the interior of each compartment. Headroom in walking and working areas shall permit normal operations required in each space without undue interference caused by striking objects overhead. Piping and wiring installations shall be installed as close to the overhead as possible. A clear headroom of 6 feet 5 inches (196 cm) is required in all walking and working areas.

3.071.1.1 Whenever possible, machinery, piping, operating rods, brackets, and other items that restrict passage or are a source of danger to personnel, shall be kept clear of normal routes of access. Where such installations cannot be avoided, guards or protective padding shall be provided.

3.072 <u>Shock</u>

3.072.1 General Requirements

The requirements of this Section apply to shock resistance for non-contact underwater explosions and other weapons effect requirements. Where military or other applicable Government specifications require shock protection for other purposes (such as for transportation shock), the requirements of such specifications shall also apply.

Unless otherwise indicated by these Specifications, the fact that Contractor-Furnished Materials (CFM) may be covered by NAVSEA standard drawings or Government Specifications does not exempt the Contractor from his responsibility to meet the shock requirements.

Items listed in Qualified Products Lists (QPLs) do not necessarily satisfy the shock requirements contained in this Section. The procedures described in this Section for extension of previous shock test qualification shall apply.

3.072.2 Shock Grade Criteria

The required level of shock resistance of shipboard equipment and systems is defined by grade.

3.072.2.1 Grade A. - Grade A systems, subsystems, or items are those which are considered by NAVSEA to be essential for the safety and combat capability of the ship. Equipment, systems, and installations required for the ship to retain the following capabilities during and after underwater explosion without significant impairment shall be designated Grade A:

a. Propulsion system.
b. Electrical generation system.
c. Ship control.
d. Casualty control, damage control and firefighting systems.
e. Interior Communication and data processing systems needed for support of the capabilities in this list.
f. Command and control system.
g. Other systems needed for direct and vital support of the capabilities in this list.

Unless otherwise specified herein, items which comprise a Grade A system or subsystem shall be designated Grade A.

Shock testing or shock design of Grade A items, in accordance with these Specifications, shall demonstrate that the item will continue to perform its principal function without significant change in performance, and that no portion of the Grade A item will come adrift or otherwise become a hazard during or after shock loading while operating.

Shock test or shock design acceptance of Grade A equipments shall not be contingent upon the ability of Grade A equipment to satisfy noise and vibration specifications after exposure to shock, unless otherwise specified.

3.072.2.2. **Grade B** Grade B items are non-Grade A items which must be capable of withstanding shock loadings without coming adrift or otherwise creating a hazard to personnel or to Grade A items or to personnel. Non-Grade A items which could constitute a hazard as defined herein shall be designated Grade B. For purposes of this Section, an item constitutes a hazard if, as a result of shock, it is possible for it, or a portion of it, to:

a. Strike and injure personnel who are operating or manning Grade A equipment, or who are at their watch stations.
b. Strike and cause significant impairment or malfunction of Grade A items or systems.

c. Cause an electrical short (as a result of internal damage or as a result of coming adrift and striking an electrical conductor) in any electrical system which is not protected by Grade A circuit breakers.

d. Cause an electrical short which could possibly result in loss of electrical power to a Grade A system, cause functional impairment of a Grade A system, or cause ignition of flammable fluids, flammable gases, or ordnance.

e. Cause release of injurious, flammable, radioactive, or other hazardous materials, fluids, or gases as a result of coming adrift and striking another item

f. Affect electrical, hydraulic, water, or any other services required by a Grade A system to the extent that significant impairment or malfunction of the Grade A system might result.

For the purposes of determining whether or not an item could constitute a hazard as a result of coming adrift, it shall be assumed that an item will not be projected beyond the envelopes specified herein. (In these definitions, the word "deck" refers to any extended surface or structure which will limit the downward motion of the item. The word "bulkhead" refers to any vertical or steeply inclined surface.)

a. The upper boundary of the envelope is a horizontal plane 2 feet (.6 m) above the highest point of the item. The lateral envelope (defined below) extends upward to this plane and downward to the deck.

b. For cases in which the distance between the deck and the highest point of the item does not exceed 5 feet (1.5 m), the lateral envelope all around shall equal the greatest dimension of the item (with foundation), but shall not be greater than 5 feet (1.5 m) nor less than 2 feet (.6 m).

c. For deck mounted items whose highest point is more than 5 feet (1.5 m) above the deck, the lateral envelope all around shall equal the distance between the deck and the highest point of the item.

d. For bulkhead, overhead, or mast mounted items whose highest point is more than 5 feet (1.5 m) above the deck, the lateral envelope all around shall equal the height of the item itself (top to bottom, including foundation) plus one-half of the distance between the deck and the lower edge of the item (with foundation). For items in this category whose longest lateral dimension exceeds 5 feet (1.5 m), the lateral envelope all around shall not be less than 5 feet (1.5 m).

The envelopes specified herein shall be modified as deemed appropriate to account for the intervening structure. Envelopes for items mounted in a manner not specified herein shall be developed in a manner which reflects the intent of these requirements.

Non-Grade A items mounted to the overhead of all ship spaces shall be designated Grade B, unless it is apparent that the item in question will not present a significant impact threat to personnel.

Shock testing or shock design of the above Grade B items in accordance with these Specifications shall demonstrate that the item will not become a hazard during or after attack. Grade B items shall be operated during shock tests (or shall be assumed to be operating for shock design purposes), if operation during exposure to shock increases the potential for shock hazards.

3.072.2.3 Foundation Shock Grades. - Foundations shall be assigned the same shock grade as the supported item, and shall satisfy the applicable shock requirements contained in this Section.

3.072.2.4 Shock Grade Not Identified. - In cases where the shock grade of any system, subsystem or item is not specifically identified by these Specifications and cannot be directly determined by application of specific shock grade selection criteria contained herein, Grade B shock requirements (depending upon whether or not a hazard would result) shall initially be assumed to apply. Items lacking in shock grade information shall be noted in the shock qualifications data sheet that the shock grade in question has not been identified by these Specifications, and shall recommend (with appropriate accompanying rationale) a suitable shock grade designation.

3.072.3 Shock Testing Requirements

Unless specifically excepted by these Specifications, Grade A and B items shall be shock qualified by shock testing in accordance with MIL-S-901D dated 17 March 1989. Shock test reports shall be prepared in accordance with MIL-S-901D dated 17 March 1989.

GFM shall not be subjected to shock testing by the Contractor, unless specifically approved by NAVSEA. When CFM is shock tested, any GFM contained therein shall be simulated by equivalent dummy loads as specified in paragraph 3.1.7 of MIL-S-901D dated 17 March 1989 and subject to Navy approval, unless otherwise specified.

3.072.3.1 Resiliently Mounted Systems. - Items which are to be resiliently mounted for noise or vibration isolation shall be shock tested while installed on the same type of resilient mounting, including buffers (snubbers), that is to be used for shipboard installation. However, items which were originally shock tested in a rigidly mounted configuration may be installed upon Distributed Isolation Material (DIM) without further shock testing. The mountings used during the shock test shall not be used aboard ship.

Where identical items are to be installed in several mounting configurations, shock testing of the item in each configuration shall be required. Shock mountings (resilient or non-resilient mounts expressly intended to mitigate shock loadings) shall not be employed during testing unless supplied as part of the original equipment or specifically approved by the Government.

3.072.3.2 Piping System Components. - Piping system supports are defined herein as hangers, sway braces, snubbers, and any other devices utilized to locate, support or limit the motion of piping.

Piping supports identical to designs which have previously been shock tested and approved, and piping supports which are in accordance with approved standard drawings may be utilized with no further shock testing required.

Piping supports which are similar, but not identical, to designs depicted on approved standard drawings may be utilized with no further shock testing, provided that design differences do not exceed the differences allowed for shock test extension.

The following criteria apply to extension of piping support shock test qualification:

a. Piping support shock test qualification may be extended to cover piping supports of different sizes, but may not be extended to cover supports of different designs. When extending to a larger size which supports more weight than the originally qualified version, or to a longer (thus heavier) support, it shall be shown that the load carrying capacity of members which comprise the support has been suitably increased to ensure equal or better shock resistance.

b. Shock test qualification of a piping support which is sized to accommodate a pipe of given outside diameter (D) may, subject to other limitations cited in this Section, be extended to cover similarly designed supports sized for pipes whose diameters range from approximately 1/2 (D) to approximately 1-1/2 (D). Test of a 2 inch (51 mm) size qualifies smaller sizes of the same or similar design.

c. Shock test qualification of piping supports may be extended only to similar supports whose standoff length is at least as great as the originally tested design.

Piping supports which are not specifically intended to locate or anchor piping in a particular position, and which cannot be shock qualified by any of the above methods, shall be shock qualified on the basis of shock testing in accordance with MIL-S-901D dated 17 March 1989 in the following manner:

a. A single support shall be shock tested while centrally supporting a straight run of piping. Ends of the pipe shall not be supported (except by flexible sway braces, if necessary to stabilize the test arrangement).

b. Dummy weights shall be added to the supported piping, as necessary, to achieve a supported weight equal to the maximum rated operating load of the support. Such dummy weights shall be located immediately adjacent to the support.

c. The length of piping supported shall be approximately equal to the typical distance between supports (as arranged aboard ship). However, where shock test facility space limitations prevent the use of a sufficient length of piping, the support may be tested while supporting a concentrated weight simulating the weight of the length of piping and its contained fluid. The dummy weight shall equal the maximum rated operating load of the support.

Shock testing of piping supports shall demonstrate that the piping support does not fracture or lose parts. Also, all such piping supports shall be demonstrated that they are capable of accommodating a 1 inch (25 mm) motion of the pipe in a direction parallel to the axis of the pipe (measured at the point of the supported pipe), and a 3 degree angular deflection (1-1/2 degrees deflection in all directions from any rest position) of the pipe about any axis perpendicular to the pipe, without sustaining failures which would violate the above shock test acceptance criteria. The ability to accommodate these piping motions shall be demonstrated analytically or by static tests, and evidence of such demonstration shall be contained in the shock test report.

Piping supports which are specifically intended to locate or anchor piping in a particular position (for example, piping supports which cannot be permitted to yield due to shock) shall be shock qualified through application of one of the following procedures:

a. The rigid support shall be designed to withstand the maximum bending and axial loads which can be transmitted by the supported pipe (for example, to loads which would cause yielding of the pipe).

b. The rigid support shall be treated as a foundation and designed to suit the criteria specified herein.

Orifices, flexible hose, and piping system components whose sole function is to provide a means for transport of fluid (such as piping, tees and elbows) and which comply with MIL-STD-777 do not require shock qualification. Standard flanges and simple bolt-on covers or blanks do not require shock qualification. All other piping system components, such as expansion joints, traps, strainers, valves and gauges, shall be assigned shock grades in accordance with these Specifications, and shall be qualified in accordance with MIL-S-901D dated 17 March 1989.

Shock test and shock test extension criteria applicable to valves shall be in accordance with MIL-STD-798. Seawater system hull valves which have been subjected to shock tests shall not be installed as sea valves but may, after proper examination and testing, be used as line valves when found to satisfy the requirements of MIL-STD-798.

The shock testing of flexible piping connections is not required, if connection lengths and allowable angular displacements are demonstrated by the Contractor to be sufficient to accommodate the maximum possible shock-induced relative motions between the points of connection.

Piping components and piping arrangements supplied integral with equipment which has been shock tested or designed for shock in accordance with criteria specified elsewhere in this Section are exempt from further shock requirements.

3.072.3.3 Tanks. - Tanks shall be shock qualified on the basis of shock testing or dynamic analysis. For dynamic analysis purposes, the tank may be regarded as a foundation and designed in accordance with the requirements for shock design of the foundations specified herein.

3.072.4 Shock Design of Foundations

Foundations for Grade A and B items which have not been shock tested with the mounted items (or simulated equipments) shall be dynamically designed in accordance with TBD. Foundations for items which are designed to shock analysis requirements shall be included and qualified for shock in the shock analysis of the item.

Grade A and B stowage racks and subbases, if not shock tested in the fully loaded configuration, shall be treated as foundations for the purposes of establishing shock requirements.

3.072.5 Shock Design of Non-Shock Testable Items

In the event non-shock testable items are identified during the term of the Contract, shock qualification of such items shall be by finite element analysis with loads/inputs derived in accordance with TBD.

3.072.6 Shock Design of Grade B Items

In cases where items are designated Grade B solely because the item, or portions thereof, might constitute a hazard by coming adrift due to shock, assurance that the item will not come adrift may, subject to Navy approval, be demonstrated by shock analysis procedures in lieu of shock testing by the contractor.

3.072.7 General Arrangement Criteria

The effects of shock-induced deflections of decks, platforms, bulkheads and hull structure shall be considered when determining the arrangement of piping, waveguide, cabling, and other contiguous components or systems, and when determining the arrangement of items installed immediately adjacent to these structures. The Contractor shall apply the following specific considerations:

a. Wetted Hull Planking - Assume that wetted hull planking will have an excursion inboard of 4 inches midspan.

b. Transient Deflections - Assume that decks, bulkheads and platforms will experience diaphragm mode elastic deflections of 2 inches midspan. The "stretching" effect of these deflections upon contiguous systems which are attached to and run parallel to the deck, platform or bulkhead in question may be neglected.

c. Deflections Across a Compartment or Space - It may be assumed that maximum relative shock-induced displacements between decks, between bulkheads, or between decks and platforms in a given space or compartment will not exceed 2 inches midspan.

d. Relative Motion Between Stanchions or Bulkheads and Decks or Platforms - Lightweight and mediumweight Grade A items shall not be attached to or installed directly over stanchions.

e. General Criteria - No Grade A or B item or system shall be rigidly attached to two structures which can deflect relative to each other to the extent that Grade A or B requirements would be compromised.

For cabling runs, it shall be assumed that an adequate combination of cable slack and cable support flexibility is provided to safely accommodate relative motion between points of attachment.

3.072.8 Shock Qualification Data

The Contractor shall prepare a data sheet to identify shock grade, status of qualification, and method of qualification for CFE Grade A and B items.

3.072.9 Extension of Previous Shock Qualification

Where an item is similar to a previously approved item, but not identical as described above, the Contractor shall prepare a request for shock test extension in accordance with MIL-S-901D dated 17 March 1989

Criteria and requirements applicable to shock test extension (with the exception of requirements related to shock test parameters and shock test documentation) shall apply in such cases.

3.072.10 Foundation Shock Analysis

Shock analysis shall be performed for foundations other than the cradles. These analyses shall be as defined in TBD. A diverse representative sampling of ten foundation shock analyses shall be prepared. Selection of foundations to be included in this sample shall be as recommended by the Contractor and approved by NAVSEA.

3.072.11 Review and Approval of Finite Element Analysis of Major Items

These criteria apply to finite element analyses of non-shock testable items which require shock qualification by design.

The Contractor shall prepare a summary report of stresses and deflections calculated by finite element analysis procedures. This summary shall cover areas which are considered to be critical under shock loading, include sample calculations, and identify calculated shock-induced stresses (or the combined shock and continuous operating stresses) and allowable stresses.

For non-shock testable items requiring qualification, the complete finite element analysis shall be approved by NAVSEA prior to design release for fabrication of these items, unless an earlier design release is specifically approved by NAVSEA.

3.072.12 Review and Approval of Shock Analysis of Grade B Items

Shock analysis of Grade B items performed in accordance with this Section shall, for review and approval purposes, be subject to the same requirements as shock analysis for major items which are designed directly to dynamic analysis.

3.073 <u>Noise, Vibration and Resilient Mountings</u>

3.073.1 Definitions. In addition to the definitions contained in MIL-STD-167-1 and MIL-STD-740-2, the following definitions are applicable to these specifications:

a) Sound Pressure Level (Lp) – The sound pressure level in decibels is 20 times the logarithm to the base 10 of the ratio of the root-mean-square (rms) pressure of the sound-of-interest at a given location to the reference pressure. For airborne sound pressure level, the reference pressure is 20 micropascals (σPa) which equals 0.002 dynes/cm^2. For waterborne noise pressure level, the reference pressure is 1 σPa which equals 10^{-5} dynes/cm^2.

b) Acceleration Level (La) – The acceleration level in decibels is 20 times the logarithm to the base 10 of the ratio of the rms acceleration of the vibration-of-interest to the reference acceleration. For these specifications, the reference acceleration is 10^{-4} cm/sec^2.

c) Structureborne Noise – Structureborne noise is the vibration in or by solid bodies such as machinery, foundations or ship structure. As used herein, structureborne noise levels are the acceleration levels in decibels, as measured in accordance with procedures specified in MIL-STD-740-2.

d) Compound Mounting/Intermediate Mass – Compound mounting refers to a sound isolation system that has resilient mounts in series, but isolated from each other by an intermediate mass (structure). The purposes of the intermediate mass are to maintain alignment of the resilient mounts above and below, under all ship operating conditions and motions, and to provide a high mechanical impedance at the support points for the resilient mounts in order to make the mounts effective. The purpose of compound mounting is to achieve a higher degree of structureborne noise attenuation than that provided by a standard resilient mount sound isolation system.

e) Radiated Noise – The ship's radiated noise level, as it applies to minecraft, is a measure of the vulnerability of the ship to acoustically activated mines. It is measured at specified ship speeds, tow loads and machinery operating conditions by having the ship pass over a calibrated hydrophone to determine the radiated noise signature of the ship over a specified frequency range, corrected to a specified reference depth and sound pressure.

f) Sonar Self-Noise – The sonar self-noise at the AN/SQQ-32 sonar array is a measure of the impact on sonar performance of the noise produced by the ship as determined by measurements at the beamformer output of the sonar receiver, when not controlled by ambient noise.

g) Sound Short – A sound short is defined as the touching of any portion of a resiliently mounted or compound mounted system with any other ship system or structure under all operating and maneuvering conditions. To prevent sound shorts, adequate clearance between sound-isolated systems and structure shall be provided in accordance with this section. Portions of piping solidly attached to machinery and equipment shall be regarded as an integral part of the equipment or machinery item.

h) Subbase – Structure that is attached to machinery and equipment for the purpose of maintaining alignment during rough handling, storage, transportation, testing, ship installation and ship operating motions, and is designed to accommodate and properly support the design of the resilient mount portion of the sound isolation system by providing a high mechanical impedance at the support points for the mounts.

i) Airborne Noise Categories – These categories establish performance requirements for ship spaces, compartments, and topside locations. Airborne noise categories specified herein and the associated acceptance levels are shown in Table 073-1 of the Builder Specifications.

1. Category A - Spaces where direct speech communication must be understood with minimal error and without need for repetition. Acceptable noise levels are based on approximate talker-to-listener distances, either 3 feet (.9 meter) or 12 feet (3.6 meters). Category A-3 shall be assigned when extreme talker-to-listener distance is less than 6 feet (1.8 meters). Category A-12 shall be assigned when the extreme talker-to-listener distance is 6 feet (1.8 meters) or greater.

2. Category B - Spaces where comfort of personnel in their quarters is the primary consideration; where communication considerations are secondary.
3. Category C - Spaces where it is essential to maintain especially quiet conditions.
4. Category D - High noise level areas where voice communication is not important; where ear protection is not provided, and prevention of hearing loss is the primary consideration.
5. Category E - High noise level areas where voice communication is at a short distance and high vocal effort, and where amplified speech and telephones are normally available.

j) Airborne Noise Grades – These grades define performance requirements for ship machinery and equipment based on the location of the unit in the ship. Airborne noise grades correspond to airborne noise categories (for example; Grade B equipment is required for Category B spaces). Airborne noise grade acceptance levels for machinery and equipment, where applicable, and when measured in accordance with the procedures of MIL-STD-1474, are shown in MIL-STD-1474.

3.073.2 General Requirements. Acoustic design features of this ship are part of mission performance. This section specifies the noise, vibration and resilient mounting requirements for machinery and systems affected by engine replacement.

3.073.2.1 The propulsion/SSDG plants with its mounting system shall meet airborne noise, structureborne noise, radiated noise, and sonar self-noise requirements specified herein.

3.073.2.2 Airbourne noise levels shall be as good as current equipment:

a) Engine Room _____dBA
b) Auxiliary Machinery Room _____dBA

3.073.2.3 Structureborne noise levels shall be as good as current equipment:

a) Main Engine (Curve 1)
b) SSDG (Curve 2)

3.073.2.4 Radiated noise shall be as good as previous ship signature (confidential Curve 1). Sonar self-noise: Replacement equipment shall not generate high frequency noise.

3.073.2.5 All propulsion plant systems and components including the MPDE and SSDG shall meet shock requirements of Section 3.072.

3.073.3 Resilient Mountings. New resilient mounts are required. The number and type of mountings shall be based on requirements provided in this section.

3.073.3.1 Resilient type mountings shall comply with MIL-M-19379, and MIL-M-19863 or MIL-M-21649, as applicable. Where more effective attenuation of machinery noise shall result from the use of other mountings, such mountings shall be tested and approved prior to application for shipboard use, in accordance with the applicable testing procedures MIL-M-17185A, dated 27 October 1959, modified as follows:

a) Page 8, paragraph 4.7.7.1, add the following: "For cup-type mounts which have been shock qualified (see 4.7.7.3), the static test strength load in Figure 4 shall be reduced 50 percent for both curves."

3.073.3.2 The design of each mounting system shall be such that the six natural frequencies of the system are not within 10 percent of hull critical frequencies that fall within the range of propeller blade excitation at, or above, 50 percent maximum power. In addition, the six natural frequencies of each mounting system shall not be within 10 percent of the exciting frequencies of the mounted equipment, unless specifically approved by NAVSEA. For calculation purposes, the foundations shall be assumed to be rigid. David Taylor Model Basin (DTMB) Report No. 880, dated February 1958 (DTIC No. AD 224812) shall be used for the selection and application of resilient mountings, and for the calculation of mounting system natural frequencies.

3.073.3.3 Mountings shall not be used when the temperature at the mounting exceeds 125 degrees F (52 degrees C), without prior NAVSEA approval.

3.073.3.4 For resiliently mounted machinery and equipment, sufficient clearance shall be provided to prevent the unit from striking structure, adjacent fixed or resiliently mounted units, or other fixed objects during maximum deflections (shock conditions) of the unit. Shock excursions shall be calculated using the method described in Section 1.4, Pages 1-11, of NAVSEA Publication No. 0900-LP-089-5010 (Navy Resilient Mount Handbook), and shall be based on the maximum allowable deflections of resilient mounts specified herein, or as appropriate for other approved mountings. The portions of piping rigidly attached to a resiliently mounted unit and extending to the flexible connection shall be considered as integral with the unit.

3.076 Re-engine Reliability, Availability and Maintainability (RAM)

3.076.1 General Requirements. The overall RAM requirements for this program are to perform the following tasks and provide the appropriate contract deliverables:

a) Maintainability Demonstration Plan or Procedure
b) Reliability, Maintainability Allocations, Assessments and Analysis (RMAAA)
c) Failure Modes, Effects and Criticality Analysis (FMECA)
d) Reliability and Maintainability Program Plan
e) Equipment Removal Demonstration
f) Reliability Demonstration

3.076.1.1 These requirements also apply to any additional equipment or accessories required and any equipment that is changed to accommodate the diesel engine change.

3.076.2 Accessibility to Equipment. Equipment and accessories arrangements shall permit access for operation and maintenance of systems and equipment for all maintenance levels without stopping or dismantling other systems, machinery, piping, or structure.

3.076.3 Removal of Equipment. All equipment and accessories requiring off-hull maintenance during the ship life shall be removable from its installed location through hatch openings, unless otherwise approved by the Navy.

3.076.4 Operational Availability (Ao). The overall objective of this specification is to attain an Ao as follows.

a) 0.95 or higher at a 95% confidence level for each MPDE diesel engine
b) 0.975 or higher at a 95% confidence level for each SSDE diesel engine

3.076.4.1 Ao is defined as MTBF/(MTBF + MTTR + MLDT). MTBF is the mean time between failures, MTTR is mean time to repair, MLDT is mean logistic down time. These terms are defined in the Draft Operational Availability Handbook, OPNAVINST 3000.12A. MTBF and MTTR are specified below. The main propulsion and ship service systems are to be maintained by a full service support contractor. The logistic down time shall be less than 36 hours per action.

3.076.4.2 Mean Time Between Failures (MTBF). With a 95 % confidence, the MTBF shall be a minimum 2000 hours in a shipboard installed operational environment. Failures are defined as:

a) Inability of the operator to keep the engine in a controllable state (e.g. engine runs erratically, surges, fails to maintain RPM).
b) Any type of fuel leak that is considered a safety issue and a hazard.
c) Condition where a significant leak, other than fuel, exists that would create a hazard to personnel, the equipment or the ship. This includes lube oil, jacket water or seawater leaks.
d) Failure due to overheating because the heat exchangers are obstructed or dirty. Heat exchangers are to be maintained according to PMS requirement.
e) Any rail, subbase or foundation crack that creates a hazard for operators or equipment.
f) Visible traces of metal shavings or flakes in fuel, lube oil or water jacket.
g) Presence of unusual noises, vibration or knocking of the engine.
h) Cross contamination of oil, fuel or water resulting from a leak. Consumption of excessive amounts of oil or jacket water.
i) Instances where critical component replacement has been recommended in accordance with diesel inspection criteria resulting in a system shutdown or repair before operating condition.

3.076.4.2.1 The following are not classified as failures:

a) Failures or degradation of non-mission essential components (tachometer, sensors, filters requiring replacement, minor exhaust leaks) that do not cause mission-degrading shutdown for maintenance.
b) Maintenance actions accomplished for PMS, inspections, calibrations, tests, MACHALT installation, etc.
c) Minor deficiencies discovered during PMS.
d) Instances where component replacement has been recommended in accordance with diesel inspection criteria but has not caused a system shutdown or repair before operating condition.

3.076.4.3 Mean Time to Repair (MTTR). The MTTR shall be 5 hours with a 95% confidence and have a maximum repair time of less than 24 hours for 95% of all failures.

3.076.4.4 Failure Modes, Effects and Criticality Analysis (FMECA). All failure modes shall be identified by a functional failure modes, effects, and criticality analysis. A mission degrading failure is defined as any failure that would prevent mine ships from starting and completing their respective mission profiles.

3.076.4.5 Mean Time Between Overhaul (MTBO). The MTBO shall be 15,000 hours for major engine or generator removal from the ship. The MTBO shall be based on the highest failure rate item that requires the engine to be removed from the ship. MTBO shall not be demonstrated.

3.076.5 Validation.

3.076.5.1 Accessibility to Equipment. Accessibility shall be verified by a maintainability demonstration as part of the maintainability demonstration required below. Extra tasks shall be added as necessary to demonstrate access for all maintenance.

3.076.5.2 MTBF. MTBF of 2000 hours shall be verified by analysis, including reliability and maintainability assessments and a functional failure modes, effects, and criticality analysis.

3.076.5.3 MTTR. MTTR of 5 hours with a 95% confidence and a maximum repair time of 24 hours for 95% for corrective maintenance of failures shall be verified by a maintainability demonstration. This shall be demonstrated in a shipboard operational environment.

3.078 Materials Requirements

3.078.1 Material and Components Selection. Material and components shall meet the performance requirements of this specification and be approved by NAVSEA.

3.085 Engineering Drawings

3.085.1 General Requirements. Following are execution requirements for engineering drawings to be used to replace the diesel engines and accomplish associated system modifications. Engineering drawings shall meet the minimum standards specified in ASME Y14.100 and as defined herein. Completed drawings shall be approved by the Government. Drawings shall be in the English language and contain the following features as applicable:

a) Title block with descriptive title, applicable hull, NAVSEA drawing number, preparer, checker, engineer and approval signatures.
b) Revision block describing any revisions to the drawing and their location on the drawing.
c) List of References listing all other drawings referenced throughout the drawing.
d) Dimensional Tolerance Block specifying tolerances to be applied to all dimensions shown on the drawing.
e) Weight and Moment impact to the ship to the nearest pound. Center of gravity of weight impact shall be to the nearest tenth of a foot.
f) List of Material showing complete ordering data for all material shown on the drawing.
g) General Notes as required describing design and or procedures not shown on drawing portion. These shall include administrative, engineering, removal, production, and testing type notes.
h) List of symbols used on the drawing.
i) Sufficient views to adequately describe design, installation, and removal as applicable.
j) List of references modified by the drawing.
k) All label plate information.

3.085.2 Drawing Format. Drawings shall be compatible with AutoCAD 2000 or later.

3.085.3 Level Of Detail. The installation design as shown on the drawings shall be final, complete and accurate so as to allow engine replacement without additional design work.

Drawings shall be sufficiently detailed so that no decisions affecting the features or testing of the completed installation are required by production personnel. As a minimum drawings shall contain the following:

a) All dimensioning and testing requirements controlled by realistic tolerances consistent with function and existing ship fabrication and design tolerances.
b) All manufacturing and assembly of components.
c) All procedures required for the installation shall be identified or referenced.
d) All required test criteria.
e) All safety cautions and warnings.

3.085.4 Drawing Types. The following drawing types are required.

3.085.4.1 Hull Structural. Hull Structural drawings shall be to scale. They shall show new or relocated ship's structure required for replacement of engines, and their location within the ship's compartment. They shall show how and where the new installation connects to the existing and new ship's structure, equipment and systems.

3.085.4.2 Machinery, Piping, and HVAC. Machinery, Piping, and HVAC drawings shall be to scale. They shall show all installation of new or relocated equipment and systems on the ship required for engine replacement. They shall show how and where the new installation connects to the existing systems.

3.085.4.3 Electrical/Electronic. Electrical/Electronic drawings shall show all required electrical and electronic details for installation of new or relocated equipment and systems on the ship required for engine replacement. They shall show how and where the new installation connects to the existing systems.

3.085.4.4 Arrangement. Arrangement drawings shall be to scale. They shall show all new and relocated equipment for effected ship's compartments, and their location within the compartment after engine replacement. All operation, maintenance and pull space requirements for the equipment shall be identified and dimensioned. Reference shall be made for each component to its applicable installation drawing.

3.085.4.5 Foundation Drawings. Drawings shall be prepared to show the arrangement, scantlings, material, and details of construction of foundations and structure. Location, size, and material of bolts shall also be shown. Fitted hold-down bolts or other special fastening or aligning devices shall be clearly indicated. These drawings shall also indicate where resilient mountings are to be installed and shall identify them by reference to the applicable detail drawings. Any special precautions regarding installation or alignment shall be covered in notes.

3.085.4.6 Removal. Removal drawings shall be to scale. They shall show all removal of existing equipment and systems required for engine replacement. Locations of cuts or end of removals shall be dimensioned. Foreign material exclusion procedure shall be identified.

3.085.4.7 Engine Outline. Engine Outline drawings shall be to scale. Drawings shall as a minimum show top, rear, and two side views of the engine. They shall show type and location of all connection points for ship's systems. All operation, maintenance and pull space requirements for the engine shall be identified and dimensioned. All removable components of the engine shall be identified. Mounting details shall be identified.

3.085.4.8 Test Procedures. Test procedures shall include step by step instructions for all required testing of modified and new components and systems. Boundaries of the testing shall be identified.

3.085.4.9 Engineering Calculations. Engineering calculations shall be formalized on a drawing where required. Calculations shall comply with Section 3.505 or as stated in the applicable section.

3.085.4.10 System Modification Diagrams. Each system modified as a result of engine replacement shall have a modification diagram depicting the modification and how it connects to existing systems. It shall contain all pertinent engineering data related to the modification.

3.085.5 Drawing Submittal. Drawings shall be submitted on compact disc.

3.085.5.1 Changes. Changes, or revisions resulting from the Government reviews, shall be incorporated and validated. All deficiencies noted during the verification process shall be corrected and submitted to the Government for review.

3.086 Technical Manuals, Publications and Other Data

3.086.1 General Requirements. The technical publications listed below as well as any other deliverable item or data shall be provided in the English language.

a) New Technical Manuals to update system and equipment changes as a result of any new engine interface connections.
b) Provisioning Technical Documentation (PTD) for all new, non-Navy standard stock listed items. Includes but not limited to the following part descriptive data: part assembly drawing, sub assembly drawing, part list showing part number, quantity and cost.
c) Text and data documents shall be submitted in Microsoft Word, Access or Excel format as required to best suit information being presented.
d) All drawings shall be created using AutoCAD 2000 compatible software.
e) All drawings and deliverables shall be provided via electronic storage medium such as CD and be capable of being transmitted electronically.

3.086.2 Technical Manual

3.092 Shipboard Tests

3.092.1 General Requirements for Testing. This section specifies the general requirements for the management and implementation of the Ship Acceptance Test (SAT) Program which shall be developed and conducted through delivery of the completed installation. The requirements of this section are supplemented by trial requirements specified in Section 3.094 and test requirements specified in Section 3.095. The SAT Program shall be in accordance with NAVSEA Publication No. 0900-LP-095-2010, except that Test Outlines and Test Procedures shall be in accordance with DOD-STD-2106.

3.092.1.1 Test documentation shall be submitted for approval.

3.092.1.2 Shipboard testing shall be conducted to demonstrate compliance with these specifications. The test program shall provide a progressive measurement of accomplishment toward ensuring that the ship is complete in all respects for Acceptance Trials (AT). Shipboard testing, Stages 3 through 7, shall be conducted after the system's subsystems and equipment have been installed on the ship. Testing shall also demonstrate workmanship, alignment of machinery, strength, rigidity, tightness and suitability for the purpose intended, and the provision of clearances for moving parts and for lines of sight and lines of fire.

3.092.1.3 The materials, power, equipment, instrumentation and shipyard services and personnel necessary to conduct each test shall be provided.

3.092.1.4 Safety precautions shall be implemented and followed to eliminate or reduce the risk of injury to personnel or damage to equipment during tests where the following or similar conditions exists:

a) When personnel or equipment may come into contact with energized circuits.
b) When lines, fittings and machinery are placed under test loads and the possibility exists that the line may part, fittings may fail or attachment points may fail.

3.092.2 Test Documentation. The test documentation specified herein shall be prepared.

3.092.2.1 Comprehensive Test Plan (CTP). The CTP shall define the test and evaluation requirements of these specifications. The CTP shall define the test organization, documentation development and control processes, interfaces between the test organization and other organizations, quality assurance provisions, processes for test conduct, processes for control and handling of test equipment, and systems or equipments recommended for special test efforts.

3.092.2.2 Ship Acceptance Test Index (TI). The TI is a composite tabular listing by test number and title of the tests to be conducted. Revisions shall be identified and shown. The TI indicates Test Procedure preparation responsibility. The test numbers and titles are based on the requirements of this section, and of Sections 3.094 and 3.095.

3.092.2.3 Test Procedures. Test procedures shall be prepared in accordance with DOD-STD-2106. Only approved test procedures shall be used.

3.092.2.4 Test Sequence Networks (TSNs). TSNs portray the desired sequence for the conduct of the test program. The TSN shall be a composite of all test procedures integrated into a logical sequence of test events to present a completely tested ship. The TSN shall be used in the preparation of the SAT Schedule.

3.092.2.5 Test Numbering. The test numbering system contained in NAVSEA Publication Nos. S9040-AA-IDX-010/SWBS 5D, first three digits, and S9040-AA-IDX-020/SWBS 5D, Appendix A, shall be used to assign identifying numbers to test documentation. The same number shall be assigned to the test documentation and data associated with a particular test.

3.092.2.6 Ship Acceptance Test Procedures. SAT procedures shall be developed. Test procedures shall be developed in accordance with DOD-STD-2106.

3.092.2.6.1 Test procedures previously approved may be used in lieu of developing new test procedures provided the conditions of DOD-STD-2106 are met. The previously used test procedure shall be submitted as a new test procedure.

3.092.2.7 Ship Acceptance Test Reports. Test reports shall document the overall test results and findings in relation to technical specification requirements. The reports shall include the test procedure, completed data sheets and results of analysis of the raw data records taken at the time of test. A test report for each test shall be prepared as it is completed during the ship acceptance test program.

3.092.2.8 Ship Acceptance Test Schedule. A SAT Schedule shall be prepared. The SAT Schedule shall depict the logical flow and planned dates for the conduct of each test listed in the TI. The test schedule shall serve as a planning document. It shall be based on the TI.

3.092.3 Test Documentation Change Control

3.092.3.1 Test Change Proposal (TCP). Test Change Proposals for proposed alterations to approved test documentation shhall be prepared prior to performing the test. Approved TCPs provide the authority to make changes to the TI, TO and TSNs and SAT Procedures. Multiple alterations to test documents or multiple documents may be proposed on one TCP.

3.092.3.2 Test Problem Report (TPR). TPRs shall be prepared when any portion of a test cannot be satisfactorily completed. A TPR shall be prepared for each test problem encountered. The Problem Investigation Report shall recommend corrective action. The TPR shall include a problem description, an assessment of the problem's impact, and a proposed resolution of the encountered problem.

3.092.4 Test Conduct. Conduct all testing using the appropriate SAT Procedure. The satisfactory completion of the test procedure as documented by the SAT Report shall serve to demonstrate compliance with the related technical requirements of these specifications.

3.092.4.1 To minimize rescheduling and reconduct of tests, ensure that the equipment to be tested and required support and test equipment are ready for the test, including any calibration, alignment, adjustment, grooming and dry run performance as may be required. Instruments that require calibration shall have current calibration labels when used in performing any test.

3.092.4.2 Tests shall be performed in accordance with the latest revision of the SAT Schedule. Provide a weekly confirmation of the intent to conduct tests as scheduled for the following week.

3.092.4.3 Provide notification if a test has been confirmed and is subsequently cancelled or deferred for any reason. Cause of cancellation or deferral, current or planned corrective action, effect on other tests and rescheduling information shall be provided.

3.092.4.4 Ensure that industrial work is completed in compartments containing major electronic equipment prior to the initial light off and testing of that equipment.

3.092.4.5 Each test shall be conducted and certified. No test shall be started without prior notification. Unless otherwise authorized, each test shall be performed using the latest issue of the approved test procedure, including as appropriate any revision, change or test problem report resolution that is in effect at the time the test is commenced. Each test shall be conducted in accordance with step by step instructions contained in the test procedure. Except as required by the test procedure, adjustments of equipment being tested shall not be made during the test conduct.

3.092.4.6 A test shall be stopped if the equipment being tested fails to meet the acceptance criteria of the test procedure. The cause of the failure shall be identified. The testing of those parts of the test which are not affected by the failure may continue. After correction of the failure, the test procedure shall be rerun except that those steps previously accomplished and not affected by the failure or correction need not be repeated.

3.092.4.7 Test data shall include any marked-up pages of the test procedure, completed data and comment sheets and supporting data such as computer printouts, strip charts, oscillograph recordings, magnetic tapes and photographs. Test data which are not an integral part of the test procedures shall be annotated with the test number, hull number, date and any other pertinent information.

3.092.4.8 A Test Problem Report shall be prepared when a test problem is encountered during test conduct. A problem exists when any portion of the test procedure cannot be satisfactorily completed as scheduled because of procedural discrepancies, tolerance deviations, design limitations, equipment characteristics or hardware discrepancies.

3.092.4.9 When changes or deviations to test procedures or corrective actions are made during test conduct, a Test Problem Report shall be prepared and submitted within 24 hours. If the TPR is not approved, the test shall be reconducted in whole or in part.

3.092.4.10 Perform corrective action in accordance with the approved TPR.

3.092.5 Test Task Group (TTG). A TTG shall be established. The test task group shall be the primary activity responsible for processing and resolving test change proposals and test problem reports.

3.092.6 Availability Periods. Periods of time to allow for inspection of equipment, subsystems or systems shall be provided. During the specified access availability periods, comply with the following requirements:

a) Provide ship services, such as power, cooling water and air conditioning and shipyard services, such as crane service.
b) Provide technical and operator personnel.
c) Permit NAVSEA personnel or authorized representatives to operate equipment, subsystems or systems as required, and allow these representatives to assist personnel in equipment and system fault isolation and correction.

3.092.6.1 The availability periods shall be indicated on the SAT Schedule.

3.092.7 Certification Requirements. Actions required to obtain certifications specified herein shall be initiated. For ABS or USCG certifications, the appropriate regulatory representative shall be notified. For other certifications, assemble the Test Reports relating to the item to be certified and forward the assembled package to the approving authority.

3.092.7.1 Unless otherwise specified, certifications shall be accomplished prior to Builder's Sea Trials. Certifications shall be assigned a test number and title in the same manner as test procedures and shall be included in the test index and test schedule.

3.092.7.2 Certification test reports shall be prepared.
3.092.7.3 When certification criteria are not met, a TPR shall be prepared. Corrective action shall be taken in accordance with the approved TPR.

3.094 Ship Trials

3.094.1 Definitions.

a) Builder's Trials (BT) – Ship trials conducted to demonstrate the readiness of the ship for AT. BT is conducted in two phases:
   1. Builder's Dock Trials (BDT) – Test and trials conducted to demonstrate to the readiness of machinery, equipment and systems for sea trials.
   2. Builder's Sea Trials (BST) – Ship trials conducted as soon as practical after BDT, and are required to demonstrate that the ship is seaworthy and machinery, equipment and systems are ready for AT. Tests and trials that cannot be performed with the ship moored are accomplished during BST.

b) Acceptance Trials (AT) – Ship trials and a material inspection conducted underway and in-port by a Navy Board of Inspection and Survey (INSURV) to determine suitability for acceptance of the ship.

c) Final Contract Trials (FCT) – Trials and material inspections conducted underway and in-port by INSURV after AT and prior to the end of the guarantee period for the ship. The object of such trials is to determine if there is any weakness, defect, failure, breakdown or deterioration, other than that due to normal wear and tear, which has not been corrected.

3.094.2 General. This section contains information regarding the scope of trials that shall be conducted to ascertain compliance with requirements.

3.094.2.1 The trials shall be conducted in general accordance with INSURVINST 4730.1.

3.094.2.2 The BDT, BST and AT time periods shall be shown on the Ship Acceptance Test (SAT) Schedule. The submittal date of BST and AT agendas shall be shown on the SAT Schedule.

3.094.2.3 When replacement of the diesel engines is complete, dock and sea trials shall be conducted to demonstrate performance of the engines to prove conformity with these specifications. Trial requirements specified herein are supplementary to the general requirements for testing contained in Section 3.092 and to specific test requirements specified in Section 3.095.

3.094.2.4 The trials to be conducted shall include the following:

a) Builder's Trials (BT):
   1. Builder's Dock Trials (BDT)
   2. Builder's Sea Trials (BST)

b) Acceptance Trials (AT)

3.094.2.4.1 In addition, Final Contract Trials (FCT) and Performance and Special Trials may be conducted.

3.094.2.5 BT shall be witnessed by Government observers. The AT shall be witnessed by INSURV and other Government observers. Sea trials shall be in navigable waters. During BST or AT the ship shall be operated in a manner and in waters suitable for collection of data for the approved trial. Sea trials shall be run as close to full load and design trim as possible.

3.094.2.6 Prior to trials, the ship shall be equipped with the safety, firefighting and lifesaving apparatus required by USCG. Prior to the start of BDT, the following shall be completed:

a) Alarm systems shall be fully operational.

b) Interior communication systems shall be fully operational.
c) Gauges and safety devices shall be checked and final adjustments completed.

3.094.2.7 Temporary rigging, industrial equipment, and debris shall be removed from the ship before sea trials. Paint shall be dry at the time of trials. Operational tests of systems whose malfunctioning could jeopardize the safety of the ship shall have been completed prior to BST.

3.094.2.8 The ship shall be in a state of material readiness for any emergency possible at sea, including collision or any other catastrophe. The minimum readiness shall include the following:

a) The RIB and its crane shall be fully operational.
b) Inflatable lifeboats shall be properly stowed. Inspection of the lifeboats within six months prior to BST and within six months prior to AT shall be verified.
c) Emergency radios shall be onboard during trials and stowed in accordance with the drawings.
d) Life rings and float lights shall be in stowage brackets.
e) Life jackets for all personnel embarked plus 5 percent spares shall be onboard and properly distributed in readily accessible areas.
f) Emergency escape breathing devices, and any other personnel escape or protective devices shall be onboard and properly stowed.
g) Medical equipment shall be stowed onboard and accessible for immediate use during trials.
h) Firefighting and damage control shall be onboard and properly stowed for the sea trials.
i) Portable damage control equipment shall be onboard and properly stowed.
j) Fire and abandon ship bills shall be prepared and drills held as part of BST and AT preparation.
k) Navigation-at-sea devices and equipment shall have been tested and onboard.
l) Compartments shall have been completed and satisfactorily tested.
m) Main subdivision bulkheads and watertight decks (bulkhead deck and below) shall have been completed and tested.

3.094.2.8.1 The readiness of these items shall be certified in writing and shall be provided to INSURV upon arrival at the ship for the AT.

3.094.2.9 Notification of Trial Dates. Trial dates shall be included in the SAT Schedule. Trial dates for BT shall be subject to approval. Trial dates for AT shall be subject to INSURV's approval.

3.094.2.10 Trial Agenda. Separate trial agendas shall be prepared for BST and AT. Events shall be arranged to permit expeditious conduct with minimum interference between concurrent events. Mutually compatible events may be scheduled simultaneously. An event is either an administrative occurrence, an inspection, or a test. Test procedures shall be prepared for each event, where appropriate. The BST agenda shall be subject to the Supervisor's approval, and the AT agenda shall be subject to INSURV's approval.

3.094.2.11 Terminations. If unfavorable weather conditions exist during the course of trials, which would endanger the ship, the trial shall be terminated and rescheduled. The trials shall be rescheduled, subject to the approval for BST and of INSURV for AT.

3.094.2.11.1 Trials shall also be terminated and rescheduled in cases where scheduled trial time is not sufficient to determine the performance of the ship.

3.094.2.12 Additional Trials. If any part of the ship or its equipment fails to meet requirements during BST or AT, additional trials shall be conducted as directed. Deficiencies shall be corrected prior to additional trials. The number, scope and scheduling of such additional trials shall be as agreed to and, in the event of a rescheduled AT, as approved by INSURV.

3.094.3 Instrumentation and Equipment. Calibration data certifying the accuracy of the instrumentation, in accordance with NCSL Z540-1, or the procedures of an approved commercial laboratory, shall be provided.

3.094.3.1 Shaft power shall be measured and computed with the use of trial torsionmeters.

3.094.3.2 Fuel consumption shall be measured by calibrated flow meters

3.094.3.3 Flow meters shall be calibrated by both before and after trials. Other instrumentation, either temporary or permanent, used to collect data for trials, shall have current calibration labels attached to ensure that such instrumentation provides reliable data.

3.094.4 Builder's Trials (BT). BT shall be conducted to demonstrate compliance with requirements with respect to performance of the ship and its equipment and systems and to verify that the ship is ready for AT.

3.094.4.1 Readiness for Sea Trials Report. Prior to BST, a readiness for sea trials report shall be prepared. The certification shall also identify and schedule for completion those items that shall be incomplete at BST.

3.094.4.2 Builder's Dock Trials (BDT). Tests and trials that can be properly conducted dockside shall be satisfactorily completed, deficiencies corrected, and tests rerun, where necessary. Should it be impractical to conduct any tests dockside, the test may be conducted during BST.

3.094.4.3 Builder's Sea Trials (BST). Successful completion of BST is a prerequisite to the conduct of AT.

3.094.4.4 Design Full Power Ahead. Continuous operation at full power ahead shall be demonstrated as specified in Section 3.095.

3.094.4.5 Endurance Power and Partial Powers. Operation shall be demonstrated at four hour endurance power and other powers as specified in Section 3.095.

3.094.4.6 Simulated INSURV Inspection. A simulated INSURV inspection during BST shall be conducted. The simulated inspection shall be conducted in accordance with the guidelines of INSURVINST 4730.1.

3.094.4.6.1 Cards shall be prepared describing each deficiency found and the required corrective action.

3.094.5 Acceptance Trials (AT). Conduct AT utilizing INSURVINST 4730.1 to demonstrate to INSURV compliance with requirements and to determine suitability for acceptance. Any test or trials conducted during the SAT Program or specified under BT shall be repeated during AT as requested by INSURV. Successful completion of AT is a prerequisite to acceptance.

3.094.5.1 Items of safety required for BST shall be implemented prior to beginning AT and demonstrated prior to getting underway. In addition, compartments shall be complete, including lagging, insulation, deck covering, labeling and painting. The ship shall be clean and free of debris.

3.094.5.2 Prior to AT, a readiness for sea trials report shal be prepared. The ship shall be certified ready for AT. The certification shall also identify and schedule for completion all items that shall be incomplete at AT.

3.094.5.3 Deficiencies shall be reported to INSURV upon arrival for trials. A system shall be established to ensure timely resolution and correction of waived items. Data recorded earlier during test and trials, together with analysis, shall be made available to INSURV at AT.

3.094.5.4 Notification of proposed trial dates shal be prepared and a trial agenda provided. The trial date and trial agenda are subject to the approval of INSURV.

3.094.5.5 Copies of each completed test procedure shall be made available. A tabulated list of tests not completed shall be provided and shall indicate when each test shall be completed. After completion of AT all work shall be completed or resolved.

3.094.5.6 Maintenance documentation and technical manuals shall be available during AT. Before AT, conduct conclusive performance tests of affected electronic systems during the trials. Electronic systems whose performance is affected by a restricted environment of the ship shall be scheduled in the trial agenda for testing during the underway portion of the trials. Other electronic systems shall be tested at an appropriate time during the trials.

3.094.5.7 Electronics equipment shall be energized, using ship power, for a minimum of 24 consecutive hours just prior to commencement of trials in order to reach steady-state conditions for the tests.

3.094.5.8 Upon the ship's return to the facility, selected equipment, as requested by INSURV, shall be opened and inspected. Correction of defects or deficiencies shall be accomplished. Following the examination and correction of defects or deficiencies, the equipment shall be closed and made ready for service.

3.094.5.9 Documentation of the results of AT shall be prepared.

3.094.6 Final Contract Trials (FCT). Conduct FCT, if required, to determine performance after service operation. Tests and inspections shall be conducted to demonstrate to INSURV full compliance with requirements.

3.094.6.1 Successful completion of FCT, if conducted, is a prerequisite to final acceptance.

3.095 <u>Test Requirements</u>

3.095.1 General. This section contains the general test requirements for replacement of the diesel engines.

3.095.1.1 The number of inspections and tests of a given component or installation shall be kept to a minimum consistent with the required results. Each test requirement subsection of this section is cross-referenced to its associated technical requirements by the applicable specification’s section number. For example, paragraph 3.095-300 contains the test requirements for associated technical requirements contained in Section 3.300.

3.095.2 Ship System Test.

3.095-200 General Requirements for Machinery Plant.

3.095-200.1 Builder's Dock Trials. Builder's Dock Trials (BDT) shall be performed when the installation, unit and system testing of machinery in the engineering spaces are essentially complete. The BDT shall demonstrate the readiness of the machinery installations for sea trials.

3.095-200.1.1 During the BDT, the following shall be completed:

a) The propulsion plant shall be operated continuously ahead and astern at such speeds and for such lengths of time as mooring site side-conditions allow. The machinery shall be operated for a sufficient length of time to detect and correct installation defects, and to run-in gears and bearings in preparation for the more severe operating conditions to be encountered during sea trials. Required adjustments shall be made at this time.
b) Each machinery component shall be inspected to determine ease and smoothness of operation, alignment, excessive noise and vibration, overheating of bearings and moving parts, adequacy and cleanliness of the lubrication system, elimination of steam and oil leaks, condition of packing, and visibility of gauges, thermometers and instruments.

3.095-200.2 Trials. The following status items shall be recorded prior to the initial start of each maneuver, as well as any significant changes during each maneuver:

a. Ship speed and course.
b. Sea state and direction.
c. True wind speed and direction.
d. Outside air temperature.
e. Seawater temperature.
f. Combustion air inlet temperature.
g. Machinery plant configuration.

3.095-200.3 Design Full Power Ahead. After steady operating conditions have been attained with full power ahead, continuous operation at this power for a 4 hour period shall be demonstrated. Ahead steering tests shall begin during the last ½ hour portion of the full power ahead trial. The propeller pitch may be adjusted to achieve full power shaft horsepower at design rpm in the trial condition. If the displacement of the ship at the time of trials is too light to demonstrate the full shaft horsepower of the plant, a full power test shall be run during FCT.

3.095-200.3.1 Internal combustion equipment and air compressors within the machinery room shall be operated simultaneously at some time during the design full power ahead test to demonstrate that any one piece of air breathing equipment does not interfere with the operation of other equipment.

3.095-200.4 Endurance Power and Partial Powers. Operation shall be demonstrated for two hours at endurance power and at other powers and conditions, as required, to simulate specified service operating conditions. Shaft horsepower shall be recorded during this test.

3.095-200.5 Quick Reversal. The strength of propellers and their foundations and the adequacy of reversing controls shall be demonstrated by a reversal from a steady state of full power ahead to full power astern, until the ship is dead in the water, and then back to a steady state of full power ahead. These reversals shall be accomplished at the maximum rate possible consistent with good operating practice. The reversal from full power astern to full power ahead shall be accomplished without exceeding design shaft torque.

3.095-202 Machinery Control System. Insulation resistance tests shall be performed after installation, but prior to equipment operation, in accordance with paragraph 3.095-320.

3.095-202.1 Prior to preliminary and operational tests, all remote and local control system instrumentation, equipment, and test instrumentation shall have been calibrated in accordance with manufacturer's requirements.

3.095-202.2 Manufacturers' procedures shall be complied with.

3.095-202.3 Preliminary Test. The following control system tests shall be completed prior to each sea trial:

a) All alarms shall be operationally tested to demonstrate that they are being actuated at the nominal design set points. Tests shall be performed using the installed sensors. Simulation of the measured parameters may be accomplished by appropriate means (e.g. gauge tester, controlled temperature oil bath) where actual system alarm set points shall be demonstrated.
b) All discrete transducers (e.g. limit switches) shall be tested in a manner similar to that employed for alarms.
c) All analog transducers shall be tested in a manner similar to that employed for alarms but through their normal operating range to demonstrate their accuracy.
d) Agreement between analog transducer outputs and monitoring instrumentation shall be demonstrated.
e) Demonstrate specified operation of all discrete indicators.
f) Specified operation of all data display equipment shall be demonstrated.
g) Demonstrate specified operation of all final control elements.
h) All control circuits shall be tested, in all modes and throughout all ranges as defined in Section 3.202.
i) Demonstrate all modes of transfer of propulsion units(s) control as required by Section 3.202.
j) Specified operation of all safety permissives and interlocks shall be demonstrated.
k) Demonstrate that all equipment can be operated in all modes of local control with all remote control and monitoring equipment secured.
l) The specified operation of all uninterruptable sources of standby control system energy (e.g. air, hydraulic, electrical) shall be demonstrated.

3.095-202.4 If adjustments are made during the sea trial that invalidate the results of any previous tests, those tests shall be repeated.

3.095-202.5 The following tests shall be conducted during sea trials:

a) Demonstrate agreement between each remote indication (e.g. meters, digital displays, and logged parameters) and all corresponding local indicators.
b) Demonstrate the ability to operate all equipment provided with remote control, from each remote control station.
c) Operation of all data display equipment shall be demonstrated.
d) Demonstrate of all modes of transfer of propulsion unit(s) control as required by Section 3.202.
e) Operation of all safety permissives and interlocks shall be demonstrated.

f) Demonstrate that all equipment can be operated in all modes of local control with all remote control and monitoring equipment secured.
g) The operation of all uninterruptable sources of standby control system energy (e.g. air, hydraulic, electrical) shall be demonstrated.
h) Demonstrate, using remote control, all propulsion unit configuration changes.
i) A series of steady state trial runs shall be conducted. A sufficient number of runs shall be conducted to verify automatic throttle calibration throughout the full range of operation.

3.095-202.6 Data shall be recorded for each run after the plant has come to a steady state condition. Data recorded shall include a complete data log printout and the value of the following parameters:

a) Ship's speed
b) Each propeller shaft speed.
c) Each propeller pitch.
d) Each propeller shaft torque from each torsionmeter.
e) Each automatic throttle controller position.

3.095-202.7 Diesel plant only (each propulsion diesel):

a) Engine fuel rack position.
b) Engine fuel flow rate.
c) Engine turbocharger discharge pressure.
d) Engine shaft speed.

3.095-202.8 Propulsion control system performance parameters shall be recorded during the following trial maneuvers:

a) Crash astern from maximum power ahead to maximum power astern.
b) Crash ahead from maximum power astern to maximum power ahead.
c) Crash stop from maximum power ahead – bring throttle to stop position from maximum ahead position.
d) Crash stop from maximum power astern – bring throttle to stop position from maximum astern position.
e) Crash ahead from full stop.
f) Crash astern from full stop.

3.095-202.9 Each maneuver shall be repeated for each propulsion plant configuration.

3.095-202.10 The following status items shall be recorded prior to the initiation of each maneuver:

a) Sea state, heading into the sea.
b) Wind speed, heading into the wind.
c) Outside air temperature.
d) Seawater temperature.
e) Combustion air inlet temperature.
f) Machinery plant configuration.

3.095-202.11 During the maneuvers, all parameters listed under steady state trial runs (test item i.) shall be recorded digitally, once/second using at least 8 bits/signal. Data recording shall commence prior to each maneuver to demonstrate that the machinery plant is at a steady state, and shall continue throughout the maneuver until the machinery plant achieves the new steady state condition.

3.095-233 Propulsion Internal Combustion Engines.

3.095-233.1 General. The propulsion diesel engines shall be checked for proper operation in accordance with the engine Technical Manual. Testing shall be accomplished per Section 4.4 of MIL-E-24455. For these tests, standard commercial test cells, detached accessories, diesel fuel, lubricating oil, and instrumentation may be used.

3.095-233.1.1 The tests shall include all instruments displaying engine parameters such as, but not limited to; lube oil, exhaust, freshwater, and seawater temperatures and pressures. In addition, operational tests of overspeed emergency shutdown device specified in Section 3.202 shall be performed.

3.095-233.1.2 In addition to all system tests specified in the appropriate sections of this specification, each engine shall be tested throughout its operating range to demonstrate compliance with this specification and readiness for trials.

3.095-233.2 Operational Tests; Starting Tests. Starting tests shall be performed with cold engines. Each engine shall be tested two times by starting, stopping and restarting as soon as the engine comes to rest. The following tests shall be performed to demonstrate satisfactory starting:

a) Operation of governors and overspeed trip settings.
b) Starting and running operation of all propulsion auxiliaries.

3.095-233.3 Control Operations. The following tests shall be performed to demonstrate satisfactory operation of propulsion engines:

a) With clutch disengaged, advance throttle from idle to full speed and observe tachometer to ensure maximum no-load engine speed.
b) Carefully planned errors shall be introduced into the propulsion control operating procedures to check the interlocking provided in the control equipment as specified in the referenced specifications.

3.095-233.4 Records of Test. Complete data on the performance of the propulsion system during dockside and underway trials shall be recorded.

3.095-256 Propulsion Plant Seawater Circulating and Cooling Water Systems. Piping shall be hydrostatically tested after installation, as specified in paragraph 3.095-505, with clean fresh water or clean seawater. Operational tests shall be performed as specified in paragraph 3.095-505.

3.095-259 Internal Combustion Engine, Combustion Air and Exhaust System. Prior to diesel engine operation the tightness of each engine intake and exhaust ducting system shall be tested by sealing off all openings and pressurizing each system with air at 14 inches (36 cm) water. After one hour, the pressure drop shall not exceed 7 inches (18 cm) water. If the pressure drop exceeds 7 inches (18 cm) water, the leaks shall be repaired and the system retested.

3.095-259.2 Combustion Air. Performance tests shall be conducted to verify vacuum breaker setting at 15.3 inches (38.9 cm) of water for MPDE and 8.1 inches (20.6 cm) of water for SSDG engines.

3.095-262 Lubrication Systems. Lubrication systems shall be tested with service fluid in accordance with the requirements of paragraph 3.095-505.

3.095-262.1 Sampling. Lubricating oil system/equipment shall have samples taken and analyzed in accordance with NSTM S9086-H7-STM-010/Ch. 262. Samples shall be taken from the oil source before filling system/equipment and from system/equipment immediately after Sea Trials. A minimum of two samples shall be taken from each system/equipment, and at least one sample shall be taken at each sampling point. Samples taken shall provide a representative example of system/equipment condition.

3.095-300 General Requirements for Electric Plant.

3.095-300.1 Insulation Resistance Measurement Tests. After installation, and prior to operation, insulation resistance measurements tests shall be made on all new or disturbed cabling and equipment. Precautions shall be taken to ensure that circuits and parts of regulators and rectifiers that have a voltage rating less than the test voltage are disconnected before the test voltage is applied. Separate measurements shall be made on the armature and field windings. Windings shall be thoroughly discharged before applying test voltage. Circuits or groups of circuits of equal voltage above ground shall be connected together. Circuits or groups of circuits of different voltages above ground shall be tested separately. Insulation resistance shall be measured with an insulation resistance indicating ohmmeter with an output of 500 volts DC. For those circuits that would be damaged by a 500 volt insulation tester, a low voltage ohmmeter shall be used. The test voltage shall be applied for not less than 60 seconds. The temperature of the component shall be noted and insulation resistance measurements shall be corrected to 77 degrees F (25 degrees C). Corrections shall be based on insulation resistance doubling for each 59 degrees F (15 degrees C) decrease in temperature. Insulation resistances, corrected to 77 degrees F (25 degrees C), shall not be less than the values specified in NSTM S9086-KC-STM-000/Ch. 300.

3.095-300.2 In lieu of making separate measurements, the resistance to ground of an interconnected generator and regulator or an interconnected motor and controller may be measured together as one unit.

3.095-300.3 If the combined readings of either the generator and the regulator or the motor and controller is less than 4 megohms, then separate measurements are required.

3.095-300.4 Cables. Cable insulation resistance tests shall be made in accordance with paragraph 3.095-320.

3.095-304 Electric Cable. Tests of cables after installation aboard the ship shall comply with paragraphs 3.095-320 and 3.095-406, as applicable. General voltage drop tests are not required. However, if drop-out of operating coil armatures or release of relays during motor starting, noticeable dimness of lights, loss of torque or synchro circuits, or other indications of incorrect circuit design are observed, voltage drop tests shall be made and the data recorded.

3.095-310 Ship Service Generator Sets

3.095-310.1 Performance and operational demonstrations shall be performed at dockside prior to ship's trials to establish that the system meets the specified functional performance.

Specified operation of all manual and automatic features, both local and remote, shall be demonstrated.

3.095-310.2 Tests of diesel generator sets shall be performed and documented after installation.

3.095-310.3 Prior to operation, insulation resistance tests shall be recorded in accordance with paragraph 3.095-300, and shall be recorded on the same form.

3.095-310.5 Starting Test. This test shall be performed with cold engines or engine at ambient conditions?. The generator set shall be subjected to two starts, consisting of cranking the assembled generator set until the engine starts, then stopping the engine and repeating the procedures as soon as the set comes to rest.

3.095-310.6 Shutdown. Operation of the shutdown device shall be demonstrated.

3.095-310.7 No-Load Test. The generator field flashing circuits shall be checked. These circuits shall be checked in manual voltage control and in automatic voltage control. With the unit operating at no-load, rated speed and rated voltage, the following shall be checked for proper operation:

a) Range of Manual Voltage Control - Record maximum and minimum.
b) Manual-automatic transfer switch.
c) Range of Auto Voltage Adjustment - Record maximum and minimum.
d) Range of Speed Changer - Record minimum, maximum, and time to go from minimum to maximum.

3.095-310.8 Preliminary Load Test. Using a load bank, each generator set shall be operated at full load for 45 minutes to bring it up to or near its operating temperature. During this period, the general operation of the set shall be observed and any necessary adjustments shall be made. At full load rated power factor, the range of voltage adjustment shall be checked and the maximum and minimum values recorded.

3.095-310.9 Low Oil Pressure Alarm. At least three separate test runs shall be made to determine the pressure at which the low oil pressure alarm operates.

3.095-310.10 Overspeed Trip. At least three separate test runs shall be made to determine the speed at which the overspeed trip operates.

3.095-310.11 Manual Trip. At least three separate test runs shall be made to determine that the manual trip operates satisfactorily.

3.095-310.12 Load Tests. Prior to the increasing load test, at no-load, the unit shall be adjusted to rated voltage and frequency, and shall be in isochronous mode. No adjustments shall be made during the load tests.

3.095-310.13 Increasing Load Test. After the set has been brought up to its operating temperature, it shall be operated at no-load and approximately 20, 40, 60, 80 and 100 percent of the kw rating of the set (in that order) for periods of at least 10 minutes each.

3.095-310.13.1 The voltage and frequency for the loading test shall be within +/- 2% for voltage, and –0, +1% for speed.

3.095-310.13.2 After completing the ascending load test, the voltage and frequency shall be adjusted to rated values with 100 percent load and operated at 100 percent load for 4 hours or until temperatures and conditions stabilize.

3.095-310.13.3 At each load step the following data shall be recorded, as applicable. For generators:

a) Time and Date
b) Voltage (one-phase)
c) Current (one line)
d) Power
e) Frequency or rpm
f) Power factor
g) Bearing lube oil pressure
h) Bearing temperatures
i) Stator temperatures
j) Exhaust pressure
k) Lube oil pressure, in and out of the engine
l) Lube oil strainer pressure, in and out
m) Crankcase pressure
n) Fuel pump discharge pressure
o) Fuel pressure at engine head
p) Seawater pump discharge pressure
q) Freshwater pump discharge pressure
r) Scavenger air pressure
s) Starting air pressure
t) Water heat exchanger temperature
   1. Seawater, in and out
   2. Freshwater, in and out
u) Lube oil cooler oil temperature, in and out
v) Engine freshwater temperature, in and out of the engine
w) Lube oil temperature, in and out of the engine
x) Engine exhaust temperature
y) Air intake temperature

3.095-310.14 Decreasing Load Test. The set shall be operated at the same loads as on the increasing load test, but in reverse order. Data shall be recorded as on increasing steps.

3.095-310.15 Parallel Operation. Generator sets, in combinations of two units each, shall be operated in parallel in isochronous mode. Each generator set shall be paralleled with each other generator set. With each generator operating at rated voltage and speed, no further adjustment of the speed or voltage shall be made for the duration of the test. The KW load of any generator (expressed as a percentage of its KW rating) shall not differ from the total KW load of both paralleled generators (expressed as a percentage of the total KW rating of both paralleled generators) by more than 5.0 percent as load is varied over the range of 0 to 100 % of total rated load, at 0.8 lagging power factor. One of the generators shall be paralleled with shore power and the load transferred from the generator to shore power without interruption of power.

3.095-310.15.1 Operation in Droop mode. Operate each generator individually in the speed droop mode. Starting at 0% load, verify that the speed droop is 3.3% when 100% load is reached.

3.095-310.16 Insulation Resistance After Operation. The insulation-resistance tests shall be in accordance with paragraph 3.095-300.

3.095-310.17 Transient Load Tests:

3.095-310.17.1 Single Unit Test. With the generator initially operating at rated voltage and frequency, the maximum permissible overspeed or underspeed upon application or removal of 90% rated KW load shall be 5.5% of rated speed. Based on a prescribed speed band of 1.0% (+/- .5%), the recovery time shall not exceed 2 seconds.

3.095-310.17.2 Parallel Unit Test. With two generators operating in parallel and sharing 20 percent total combined rated load, an additional 70 percent combined rated load shall be suddenly applied. After the voltage and frequency have stabilized, and without adjustment of the generator voltage, frequency or balance, the same 70 percent load shall be suddenly removed.

3.095-310.17.2.1 The following minimum data shall be recorded:

a) Steady State – Before and after each load application or removal, line-to-line voltages, line currents, frequency, kw, field voltage and field current.
b) Transient – At least one line-to-line voltage and current of each generator, timing trace and generator frequency recorded by means of an oscillograph. The voltage and frequency peak-to-peak displacement shall be of sufficient height to provide accurate measurement of transient dip and rise. Film speed shall be of sufficient speed to provide accurate timing measurement.

3.095-310.18 Maintenance of Speed Control Under the abnormal conditions listed below, the system shall maintain speed control to the extent that the generator set shall not overspeed or shut down and the prime mover shall carry load and remain on the line. In addition, the specified performance shall automatically be resumed upon restoration of normal conditions.

3.095-310.18.1 A three-phase or single-phase short circuit suddenly applied to the generator output terminals with the generator set delivering any load under normal operating conditions. Short circuit duration to be determined by $I^2t = 180$, where I is the sustained value of line current in per unit and t is the time in seconds. The sustained value of current during a three-phase or single-phase short circuit shall be not less than 3.2 time rated.

3.095-310.18.2 Loss of generator excitation; that is, sudden removal of generator excitation with the set delivering any load under normal conditions. Overspeed is defined as 105% rated speed.

3.095-320 General Requirements for Electric Power Distribution System

3.095-320.1 Insulation Resistance Tests on Power, Lighting and Control Circuits. The insulation resistance of the power, lighting and control circuits shall be measured with an insulation resistance indicating meter having a full scale reading of 100 or 200 megohms, an open circuit voltage of 500 volts, and a voltage of at least 450 volts across a resistance of 1 megohm. For methods of performing these tests, NAVSEA Publication No. S9086-KC-STM-000, Naval Ships Technical Manual, Chapter 300, shall be used as a guide. Minimum acceptable insulation resistance values shall be determined from MS-18297.

3.095-320.2 Ships Service Distribution Systems. Operation of the ship service and ship service/emergency distribution systems shall be demonstrated.

Control System. After installation of the electric plant control system, all instrumentation associated with it shall be calibrated, and operational tests performed to ensure that each controlling feature performs its specified function in accordance with Section 3.202.

3.095-406 Electromagnetic Interference (EMI).

3.095-406.1 Ship Level EMC, IMI and Broadband Surveys. The electromagnetic conditions of the ship shall be verified via execution of an EMI survey consisting of Phase I and Phase II, IMI and broadband surveys in accordance with the requirements of Project Peculiar Document, NAVSEA No. 802-6336069, and as specified herein. An EMI test procedure, in accordance with the test requirements of Project Peculiar Document, NAVSEA No. 802-6336069, shall be prepared prior to the test survey. Testing utilizing HF (2-30 MHz) transmitters shall be conducted at 400 watts output power for compliance with Project Peculiar Document, NAVSEA No. 802-6336069. CFE displaying Category 1 and Category 2 electromagnetic interference, as defined in Project Peculiar Document, NAVSEA No. 802-6336069, shall be corrected. GFE displaying Category 1 and Category 2 electromagnetic interference as a result of installation shall be corrected.

3.095-406.1.1 In addition, a full power test of the HF transmitter shall be conducted and documented.

3.095-406.1.2 After the survey, and completion of any corrective actions necessary, a test report shall be prepared detailing the results of the survey and documenting any and all modifications made to CFE or installation requirements and practices. Interference caused by GFE shall be described in the survey report in sufficient detail for the Government to determine the feasibility of correcting the interference.

3.095-406.2 Shielding Effectiveness Tests for Compartmental Shielding. The shielding effectiveness tests shall be performed with 2-30 MHz transmissions at full power and 400 watts. Testing can be coordinated with the test requirements of Project Peculiar Document, NAVSEA No. 802-6336069. The Government test shall consist of two receive antennas equally spaced from the source transmitter (shipboard HF transmit antennas). One antenna shall be located within the shielded compartment and one outside the shielded compartment. Both receive antennas shall be oriented for maximum signal response and shall be placed a minimum of 20 inches (0.5 meter) from metallic objects and a minimum of 39 inches (1 meter) from the conductive shield oriented parallel to the test antenna and 20 inches (0.5 meter) from the conductive shield oriented normal to the test antenna. The test shall be conducted on at least 12 frequencies distributed throughout 2-30 MHz. During the test, other shipboard equipment located within the compartment under test, except the Communication Center, shall not be energized.

3.095-504 Instruments and Instrument. After installation, instruments shall operate with the degree of accuracy specified herein. Instruments shall be adjusted, calibrated, repaired, replaced, or their installation features modified in accordance with manufacturer's instructions, wherever necessary, to ensure performance under all operating conditions.

3.095-505 General Requirements for Piping. Inspections and hydrostatic tests shall be completed before the system is operated. Deficiencies revealed during tests shall be corrected followed by a repeat of the test.

3.095-505.1 Welded and Brazed Joints. Tests and inspection of welded and brazed joints shall be in accordance with the requirements of S9074-AR-GIB-010/278 and NAVSEA Publication No. 0900-LP-001-7000.

3.095-505.2 Hydrostatic Pressure Tests. Reconfigured piping systems and disturbed joints shall be given a hydrostatic pressure test after installation and before operation aboard ship, after initial cleaning and flushing. The test liquid shall be either clean fresh water (drinking water grade or better), or clean (strained) seawater (seawater systems only). Joints, including welds, shall be left uninsulated and exposed for examination during the test, unless they have been previously satisfactorily tested to at least the pressure specified herein.

3.095-505.2.1 A tightness test of the piping joints at normal system operating pressure and a shop hydrostatic test at 135% of normal system pressure for the valves and components may be substituted for the strength test, provided the additional NDT requirements of NSTM S9086-RK-STM-010/Ch. 505, paragraph 505-1.4.3.6 are met.

3.095-505.3 Precautions. Expansion joints shall be provided with temporary restraint, if required for the additional test pressure load, or else they shall be isolated from the test.

3.095-505.3.1 Equipment, tanks and machinery that would be subjected to a test pressure higher than their specified test pressures shall be isolated from the system. Where a shipboard hydrostatic test is required for such equipment or machinery at a lower test pressure than the system hydrostatic test pressure, the piping attached to the equipment or machinery up to the first cutout valve may be tested with the equipment or machinery rather than at system test pressure. Equipment or machinery that could be damaged by the test liquid, or whose operation could adversely be affected due to exposure to the test liquid, shall be isolated from the system. Valves shall not be used for test isolation where the test pressure would exceed the design tightness pressure of the valve in the closed position.

3.095-505.4 Test Pressures. Unless otherwise specified, systems shall be tested at a pressure equal to 135 percent of the system design pressure, but not less than 50 psi (340 kPa). At least 30 minutes shall elapse between application of the test pressure and inspection of the first joint. Under no circumstances shall the hydrostatic test pressure exceed the original system hydrostatic test pressure unless the existing design pressure has been upgraded.

3.095-505.5 Unobstructed Flow. After hydrostatic tests, and prior to operational tests, demonstrate unobstructed flow of piping.

3.095-505.6 Operational Tests. Piping systems shall be operationally tested after cleaning and hydrostatic pressure testing to verify conformance with system design requirements in regards to flow, temperature, pressure evacuation requirements, and setting of over pressure and over temperature protection devices. Performance shall be verified in the normal, emergency and manual modes of operation. Gauges shall be checked for calibration and adjusted as necessary. Joints that were blanked during the hydrostatic test shall be inspected for tightness during the operational test. Deficiencies detected during the tests shall be corrected, followed by a repeat of the test.

3.095-512 Heating and Ventilation Systems.

3.095-512.1 Systems shall be tested and balanced to ensure delivery of designed air quantities to compartments. Before testing and balancing, the following conditions shall exist:

a) Systems shall be clean.
b) Normally-open closures, dampers and valves shall be open.
c) Fans and motors shall be checked for proper direction of rotation and speed.

d) Filters shall be clean and in place.
e) Fans shall be operated at high speed.
f) All access plates, inspection covers and fittings shall be in place.
g) If the system to be tested takes suction from, or discharges into, a plenum chamber common to other systems, the other systems shall be operated at full capacity.
h) Access to the compartment tested shall be left open, except for compartments having either natural supply or natural exhaust.
i) Access to spaces having either natural supply or natural exhaust shall be closed, unless the access is the natural supply or exhaust.
j) In machinery spaces, the heat producing equipment shall be secured.

3.095-512.2 Allowable differences between actual air quantities and design air quantities shall be as follows.

a) Systems serving the Main Machinery Room, Generator Rooms, and Auxiliary Machinery Room shall deliver not less than 100 percent of, nor more than 110 percent, of their design capacity. Where exhaust is required to be 115 percent of supply, the measured exhaust shall be between 115 percent and 125 percent of measured supply. Individual terminals within these spaces shall be balanced so that the measured quantity of ventilation air in ft^3/min at each terminal is as follows.

$Tm = (Td \pm 0.1Td)\ Qm/Qd$

Where:

Tm = terminal measured quantity
Td = terminal design quantity
Qm = system measured quantity
Qd = system design quantity

b) Ventilation systems shall deliver not less than 100 percent, nor more than 110 percent, of design capacity, and shall be balanced so that the measured quantity of ventilation air in ft^3/min to each compartment is as follows.

$Cm=(Cd \pm 0.1\ Cd)\ Qm/Qd$

Where:

Cm = compartment measured quantity.
Cd = compartment design quantity.
Qm = system measured quantity.
Qd = system design quantity.

c) Individual terminal delivery limits within these compartments shall be within plus or minus 20 percent of their prorated quantities.

3.095-512.3 **Watertight Closure Tests**. Before installation, watertight closures shall be watertight when tested under the same demonstrated pressure and strength requirements specified for the compartment protected by the closure, unless an identical design has been previously accepted.

3.095.534 Gravity Drain Systems. Gravity Drain systems shall be tested by filling with water and the water shall stand in the system until the tightness of the system has been demonstrated.

3.095-541 Fuel Systems. In addition to the general test requirements specified in paragraph 3.095-505, the tests listed herein are also applicable.

3.095-541.1 Fuel piping shall be hydrostatically tested with clean fresh water to 135 percent of the design pressure or 50 psi (340 kPa), whichever is greater. Upon completion, remove water from the pipe to the maximum extent practicable. Pumps in fuel service systems shall be isolated during hydrostatic test of system piping.

3.095-541.2 Operational Tests. The fuel service systems shall be given an operational test with service fluid at operating pressure.

3.095-551 Compressed Air Systems. In addition to the general test requirements specified in paragraph 3.095-505, the tests listed herein are also applicable. After cleaning, the systems shall be hydrostatically tested to 135 percent of system design pressure with clean fresh water. Air receivers and equipment that would be damaged by water, such as dehydrators and compressors, shall be excluded from these tests.

3.095-551.1 Tightness Tests. After the satisfactory completion of the hydrostatic tests, the compressed air systems shall be tested in accordance with NSTM S9086-SY-STM-010/Ch. 551 or as an alternative charge the system to normal operating pressure with air, apply soapy solution to new or modified joints, and hold pressure to verify zero leakage.

3.096 Weights

3.096.1 This section specifies the requirements for Weight Control with respect to alterations on the MCM1-class.

3.096.2 MCM 1 CLASS. The total weight of all installed engine and engine piping components shall not be different from the total weight of all removed engine and engine piping components. If the weight of the installed engine and engine piping components is less, weight must be added at each engine installation to maintain the ship's existing center of gravity. All removal and installation weights and lever arm moments shall be calculated and shown on system drawings. See Section 3.085.

3.096.2.1 Engine replacement in the MCM1-class requires assessment of weight effect as the engines are below the ship's vertical center of gravity. Thus a new engine of lighter weight shall cause the center of gravity to rise, which shall require compensation. A new engine of heavier weight shall require compensation by weight removal.

3.096.2.2 Ballast installations must meet Grade B shock requirements.

3.180 Foundations

3.180.1 General. Existing foundations shall be re-used to the maximum extent possible. The engine shall mount to the existing subbase. An appropriate engine to subbase adapter shall be designed and provided that meets requirements of Sections 3.072, 3.200 and 3.310. This section also contains requirements for miscellaneous foundations and supports for hanger supports, gage boards and controllers, wherever necessary.

3.180.2 Design Requirements.

3.180.2.1 Loading. Foundations shall be provided to transmit loadings from the machinery and equipment supported to the hull proper. Strength and rigidity shall be suitable to withstand the applied loads, such as:

a) Gravity and inertia forces, plus their dynamic effects with the ship in a seaway.
b) Inertia forces resulting from vibratory motion of the hull structure.
c) Loads due to the operation of the machinery or equipment itself.

3.180.2.1.1 Piping connection to machinery and equipment shall not be considered as reducing the load to be supported by foundations.

3.180.2.1.2 Foundations subjected to cyclically repeated or reversing loads shall be designed to withstand fatigue over a 20 year cycle without failure.

3.180.2.1.3 Foundations for heat exchangers shall be designed to support the additional weight of water when testing for leakage, when the heat exchanger shell is filled with water to the top of the uppermost tubes.

3.180.2.1.4 Foundations shall not resonate within the range of frequencies developed by each ship propeller, primary hull bending modes and rotational speed of the machinery. Vibration shall not prevent the ship from maintaining any speed up to and including maximum speed.

3.180.2.1.5 Foundations shall incorporate the noise and shock design features specified in Sections 3.073 and 3.072, respectively.

3.180.2.2 General Criteria. Each principal direction of shock loading (vertical, athwartship, and fore and aft) shall be considered separately. Continuous operating stresses, as defined herein, shall be added to calculated shock stresses. Comparison of calculated and allowable stresses shall generally determine design acceptability. However, it shall also be ensured that deflection of foundations shall not lead to overloading of flexible couplings or other displacement-critical components.

3.180.2.3 Design Selection.

3.180.2.3.1 Elastic Shock Design. Elastic shock design shall be used in cases where it is necessary to preserve original physical dimensions after exposure to shock. All foundations that support rotating elements in the propulsion train and foundations for other alignment-critical components shall be designed to perform elastically. Foundations for rotating auxiliary equipment shall be designed elastically, unless it is evident that plastic deformation (or tilting) of the equipment mounting surface shall not occur or shall not result in impaired equipment performance. Items to be installed that are known to be alignment sensitive (for purposes of shock design) are listed below. Omission of alignment sensitive items from this list does not relieve responsibility to ensure proper selection of shock design values for all applicable items.

a) Main Propulsion Machinery
b) SSDG

3.180.2.3.2 Elastic-Plastic Shock Design. If elastic design is not required for the reasons stated above, elastic-plastic shock design shall be used.

3.180.2.4 Allowable Design Stresses. Allowable stress criteria for elastic and elastic-plastic designs are described as follows.

3.180.2.4.1 Allowable design stresses for Grade A items designed to suit elastic shock design:

a) Where deflection is critical, stresses shall not exceed the material static yield strength (0.2 percent offset).
b) Where slight permanent deflection can be tolerated, the criterion of failure is the effective yield strength of the material. This effective yield strength is tension, ů, or shear, Ű as defined by the following:

$$\text{ů} = \text{ů}_Y + F\ (\text{ů}_U - \text{ů}_Y)$$

$$\text{Ű} = 0.6\text{ů}$$

1. In these equations ů_Y is the 0.2 percent offset yield strength, elastic limit, or other normal definition of material yield strength, ů_U is the normal definition of material failure strength, and F is a factor (some samples are given below) that takes into account the efficiency with which the material in the member being analyzed is utilized. All strengths are the values at the expected temperature, as is the modulus of elasticity. The efficiency is computed by comparing the load required to just initiate yielding of the member with the load required to have the member completely yielded (in this computation, it is assumed that the stress-strain curve of the material is bi-linear, with no strain hardening). The factor F (this efficiency minus one) is thus dependent on the kind of loading, i.e. tension, bending, etc., and on the cross-section of the member; for example, the factor is zero for any member in pure tension and 0.5 for a rectangular section in pure bending. For any brittle material, i.e., one that has less than ten percent elongation before fracture in a tension test, the factor F is always zero. The factor F must be taken as zero for any application where a slight plastic set cannot be permitted.
2. **Sample Factors F** - Consider a rectangular bar subject to pure bending. The ratio of the fully plastic moment obtained by limit analysis to the bending moment at yield is well known to be 1.5.

   So, F = 1.5 - 1 = 0.5 and the allowable stress is:

$$\text{ů} = \text{ů}_Y + 0.5\ (\text{ů}_U - \text{ů}_Y)$$

   For a typical I section:

$$F = A/\ (6 + 2A)$$

   Where:

$$A = \frac{\text{(web width)(depth of section)}}{\text{2(flange width)(flange thickness)}}$$

   For a solid shaft in bending:

$F = 0.7$

For a hollow shaft in bending:

$F = 0.913 - 0.638(R_i/R)$

Where:

R_i/R = The ratio of the inner to the outer radius; and
R_i/R = Is equal to or greater than 0.6.

If bending is combined with torsion, shear, tension or compression, then the analyst should compute the ratio of the maximum load to the yield load, and subtract one, giving him the factor F.

c) Allowable shear stress is 60 percent of the material static yield strength. Allowable bearing stresses are 160 percent of the material static yield strength.
d) Combined operating and shock loads shall not exceed allowable column loads.

3.180.2.4.2 Allowable design stresses for Grade A items designed to suit elastic-plastic shock design

a) In cases where it is necessary to limit permanent deflection to approximately twice the maximum elastic deflection, stresses shall not exceed the material static yield strength (0.2 percent offset), and shear stresses shall not exceed 60 percent of material static yield strength. Bearing stresses need not be considered.
b) In cases where considerable plastic bending can be tolerated (as is usually the case with foundations designed to suit elastic-plastic shock design values), bending stresses not exceeding 200 percent of the material static yield strength shall be considered acceptable. Shear stresses shall not exceed 120 percent of the material static yield strength in such cases. Stresses acting in axial directions shall not exceed the material static yield strength. (Note: The 120 percent allowance does not apply in cases where shear loads could cause tear-out of fasteners such as bolts, and shall not be applied to design of bolting and similar fasteners. Where 200 percent and 120 percent allowable stress criteria apply, continuous operating stresses (if present) shall be doubled before combining same with shock stresses).
c) When combined stresses are calculated, combined stress shall not exceed the material static yield strength. (Calculated shear and bending stresses subject to 200 percent and 120 percent allowable stress criteria shall be halved before inserting into the combined stress formula).
d) Column buckling need not be considered.

3.180.2.4.3 Allowable Design Stresses for Grade B Items. Allowable design stresses for Grade B items are the same as those that apply to Grade A items, except that bending stresses need not be considered in cases where it is evident that plastic bending of the members in question shall not lead to violation of Grade B criteria. In cases where the above cannot be ensured, the allowable stress criteria described previously shall apply.

3.180.2.4.4 Allowable Bolt Stresses. For bolts, where MIL-DTL-1222 applies, the elastic proof stress may be considered as the yield stress. For bolts fabricated from materials other than the materials included in MIL-DTL-1222, the material static yield strength is the allowable stress.

3.180.2.4.5 Interface Stresses. Interface stresses between foundations and GRP base structures shall remain elastic under combined shock and operational stresses. For GRP structure in way of foundations, the factor of safety between the GRP material ultimate stress and the calculated stresses shall be greater than or equal to 1.5.

3.180.2.4.6 Weight Reduction. In order to minimize foundation weight, maximum shock stresses shall exceed 75 percent (but not 100 percent) of maximum allowable tensile, compressive or shear stresses in at least one primary, that is, one main supporting structural member, for all foundations weighing more than 125 pounds, except in cases where application of this criterion would cause an increase in foundation production cost.

3.180.2.5 Combining Stresses. In order to compare the stresses produced by shock loading to a specified failure criterion, the analyst shall combine the stresses derived by dynamic analysis with those of any continuous operating stresses present in the area under consideration. Continuous operating stresses are defined as those stresses, present in the system due to the system's operating characteristics (e.g. rotating elements, fluid pressure, etc.), that shall not be relieved by minor yielding. An example of a continuous operating stress is that which is produced by the torsional effect of a rotating element. Non-continuous operating stresses, such as thermal stresses, shall be ignored. Gravity loads need not be considered. Bolt pre-tensile stress shall not be added to shock stress. To determine the combined stresses in a structural member subjected to both normal and shear stresses, the combined stress formula derived from the Octahedral Shear Stress Theory is acceptable. The formula (modified) is as follows.

$$S_{comb} = \sqrt{(S_{norm})^2 + 3(S_{shear})^2}$$

Where:

S_{norm} = The tensile or compressive stress produced by tensile, compressive or bending loads; and

S_{shear} = The shear stress produced by either shear or torsional loads.

3.180.2.5.1 For dynamic analysis purposes, when combining normal or shear stresses with a continuous operating stress at right angles to it, the normal or shear stresses shall be those summed across the modes. The combining of normal or shear stresses with a continuous operating stress of the same type (e.g. shear stresses with a continuous operating torsional stress) shall be a straight additive procedure.

3.180.2.5.2 An example of the method used to combine stresses at right angles to each other is shown below.

a) Assume a 20,000 HP shaft in an equipment is rotating at 2,000 rpm (continuous operating load). This rotation yields a continuous operating stress of:

$T = HP(12)(33,000)/2\phi(rpm)$
$T = (20,000)(12)(33,000)/(6.28)(2,000)$
$T = 630,570$ in-lbs

$S_{tors} = Td/2J$ d=7 and J=236 (assumed)
$S_{tors} = (630,570)(7)/2(236)$
$S_{tors} = 9,350$ psi

b) This torsional stress is now added to the bending stresses (summed across the modes) at the point to maximum stress (assume this to be 34,700 psi in tension).

$$S_{comb} = \sqrt{(S_{bend\ comb})^2 + 3(S_{tors})^2}$$

$$S_{comb} = \sqrt{(34{,}700)^2 + 3(9{,}350)^2}$$

$$S_{comb} = 38{,}300 \text{ psi}$$

c) This combined stress is now compared to the tensile yield point of the shaft material to determine if failure shall occur. Allowable shock stress criteria are as defined herein.

3.180.2.6 Structural Arrangement. Continuity of structure shall be provided so that loads shall be properly distributed into hull structure of adequate strength and rigidity.

3.180.2.6.1 Insofar as practicable, equipment shall be supported without direct connection to the hull or other structure subject to wave impact, contact with waves, propeller excited vibrations, or similar loadings, where the resulting distortion or vibration would damage the equipment or impair its performance.

3.180.2.6.2 Machinery and equipment shall not be attached to two structures that can move relative to each other under shock loadings. Forces that may be caused by underwater explosion shall be included in stress calculations.

3.180.2.6.3 Top bracing shall be installed on deck mounted equipment that has a ratio of height to smallest base dimensions of 3:1 or greater. Top bracing shall not extend more than 45 degrees from the horizontal. Braces shall be designed and installed to allow some vertical movement, so that the equipment is not restrained vertically between the bottom foundation and the top bracing.

3.180.2.6.4 In general, alignment between separate components of a unit shall be maintained by means of keyways or other adequate means.

3.180.2.6.5 Projecting corners and edges of structure shall be avoided. Those that cannot be eliminated shall be rounded or padded to protect personnel.

3.180.2.6.6 Accessibility for inspection and maintenance of equipment supported shall be provided in accordance with Section 3.071.

3.180.3 Attachment of Equipment to Foundations. Coamings, liners, gaskets, bolts, foundation blocks, and other material and fastenings shall be fitted, as required, for the attachment of machinery and equipment to foundations.

3.180.3.1 Connections shall be sturdy and efficient. Means shall be provided for maintaining positive and accurate alignment wherever it is essential for satisfactory operation of the machinery or equipment.

3.180.3.2 The attachment of machinery and equipment to foundations shall provide for relative movement due to thermal expansion. The arrangement shall prevent misalignment of connected units under any operating conditions.

3.180.4 Miscellaneous Requirements. Packing for throughbolts shall be provided, as required, to maintain watertightness.

3.180.4.1 Inaccessible areas of metallic foundation structure shall be coated to protect against corrosion. Stainless steel foundations shall not be coated.

3.180.4.2 Complete drainage of foundations shall be provided.

3.180.4.3 External laminate surfaces of foundations located internal to the ship shall be protected with not less than 45 ounces/yd^2 (1,500 grams/m^2) application of fire protection polyester.

3.200 <u>Propulsion Plant, General</u>

3.200.1 Definitions.

a) Machinery plant – Consists of the propulsion plants, independent auxiliary plants, independent auxiliaries and equipment, with supporting piping, electrical, and control systems required for the ship.
b) Main Propulsion Diesel Engine (MPDE) – The energy source used to drive the propulsion unit.
c) Propulsion auxiliaries – Those auxiliaries directly associated with the propulsion plant that perform functions essential to the operation of the propulsion plant.
d) Propulsion plant – Consists of the propulsion unit, propulsion auxiliaries, associated equipment, control systems, piping systems, and electrical systems that are required to drive one propeller.
e) Propulsion unit – Consists of the machinery and equipment that are mechanically, electrically, or hydraulically connected to a propulsion shaft driving one propeller.
f) Subbase – In a resiliently mounted configuration, the stiff structural platform on which the isolated machinery is rigidly mounted.

3.200.2 General Requirements. A replacement MPDE shall be provided per “Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships.”

3.200.2.1 Interface. The installed MPDE shall interface and operate with the following existing propulsion components:

a) Subbase assembly
b) Pedestal Bearing Shaft Input Flange

3.200.2.2 Gears. If new reduction gears are installed, the numbers of teeth on meshing elements shall have no common factors.

3.200.2.3 Alignment. Correct alignment shall be maintained between the components of the propulsion unit in accordance with the engine manufacturer’s specifications. Existing flexible coupling shall be used and current alignment criteria maintained.

3.200.2.3.1 Chocks. Self-leveling, corrosion resistant steel, height adjustable chocks in sufficient quantity shall be used to maintain proper alignment of the diesel engine mounting system. Chocks shall withstand loads imposed by the weight of the engine and ship's motions as well as mechanical vibration.

3.200.2.3.2 Shims. Shims shall not be used with adjustable chocks.

3.200.3 Arrangement. Arrangement of the MPDE shall permit ready accessibility for operation, inspection and maintenance. Removal of interferences such as piping, floor plates, gratings and air ducts to accommodate maintenance shall be kept to a minimum.

3.200.4 Mounting System Installation. The propulsion plant mounting system shall meet airborne noise, radiated noise and sonar self-noise requirements specified in Section 3.073. New resilient mounts are required in accordance with Section 3.073.

3.200.4.1 All systems and components of the propulsion plant, including the MPDE shall meet shock requirements of Section 3.072.

3.200.4.2 The engine shall be hard mounted to the existing subbase. The mounting system shall be compatible with the existing subbase system (including resilient mounts below the subbase, and excursion snubber system).

3.200.4.3 The quantity and location of the new resilient mounts below the subbase shall be such that each mount is loaded within its rated capacity and that sound shorts shall not occur under the dynamic loading of moderate sea conditions as defined in Section 3.070. This does not apply to sound shorts during shock excursion at which time the subbase movement shall be restricted by shock excursion snubbers; however, the subbase shall return to the resilient mount supported position, and the propulsion units shall continue to operate without sound shorts.

3.200.4.4 Emergency Shut Down Device. The emergency shutdown device from the engine shall be connected to the existing pull cable system, which can be operated from both the engine and a remote location. The emergency shutdown device shall secure flow to the injectors, shut off the air, and stop the engine without any damage within 60 seconds of activation.

3.202 <u>Machinery Control System</u>

3.202.1 Definitions.

None

3.202.2 System Overview.

The MCM-1 MCS is installed on all ships in the class.

3.202.3 General Description The engine(s) shall be capable of being remotely controlled and monitored by the Machinery Control System (MCS), made up of NT Based Workstations, Allen-Bradley Programmable Logic Controllers (PLC's) and a Fiber optic Local Area Network (FOLAN). The new engine design shall meet the requirements of the Technical Specification Main Propulsion Diesel Engine and Ship Service Diesel Engine Retrofit Application for MHC-51 and MCM-1 Class Ships. A list of engine sensor signals which are recommended for engine operation and monitoring shall be provided to the government. These signals shall interface to the MCS through a junction box or over the dedicated MCS network interface.

3.202.3.1 The engines shall be capable of manual start-up and operation at the Contractor supplied Engine Mounted Control Panel independent of MCS. Failure of all or of any part of the MCS shall not inhibit local control and monitoring of equipment on the engines.

3.202.3.2 Equipment Shielding and Filtering. Equipment and cabling installed to interface the MCS equipment and the engines shall be designed to meet the requirements of Section 3.406 [G9]– EMI Reduction.

3.202.4 Shock. Equipment installed to interface MCS to the new engines shall meet the shock requirements specified in Section 3.072.

3.202.5 Reconfiguration Boundary.

3.202.5.1 Sensor Signals Terminating at the ECU: Engine sensor signals which terminate in the ECU shall be supplied to the MCS. The method of providing the signals to the MCS is negotiable.

3.202.5.1.1 The MCS currently accepts the following device inputs and outputs:

Thermocouple
Resistance Temperature Devices (RTD)
Analog Inputs (1 to 5VDC, 0 to 5VDC, -5 to 5VDC, 0 to 10VDC,-10 to 10VDC, 4 to 20 mA, 0 to 20 mA, and -20 to 20 mA)
Analog Output (0 to 10 VDC)
Discrete Inputs (PLC 24VDC supplied source voltage to non-supervisory device contacts)
Discrete Outputs (PLC 24VDC supplied to solenoids/controllers or Dry contact outputs to switch field supplied voltage 115V AC or 24 VDC)

3.202.6.1.2 Signal Interface to the MCS should be provided in the above format via junction boxes. The terminal junction box size, type and location shall be in accordance with section . The terminal box shall be supplied by the engine manufacturer. Cabling shall be installed in accordance with 3.304.

3.202.6.1.3 Signal device input over a dedicated MCS network interface may be acceptably negotiated as long as the vendor supplies the necessary Allen-Bradley PLC5 hardware to accept the signal interface. The network interface protocol and format shall be non-proprietary free of licensing fee and compatible with MCS.[v10]

3.202.5.2 Sensor Signals Not Terminating in the ECU. Engine sensor signals which do not terminate in the ECU shall be terminated in a junction box. The terminal junction box size, type and location shall be in accordance with section . The terminal box shall be supplied by the engine manufacturer. Cabling shall be installed in accordance with 3.304.

3.202.5.3 Existing Interfaces: Junction boxes, cables and interfaces removed from the existing engine which are required for MCS will be reinstalled at a mutually agreeable location.

3.202.5.4 Sensors and controls that are within the reconfiguration boundary and that need to be modified/relocated due to re-engine work shall be returned to their as-built condition unless it is determined by the Government that it is no longer required. For example, a starter air piping valve with a limit switch which interfaces with MCS and falls within the reconfiguration boundary needs to be modified/relocated due to the new engine work, that valve (with limit switch) or equivalent shall be reinstalled and reconnected to MCS.

3.202.5.5 Engine controls and sensor wiring harness shall terminate in terminal boxes MIL-T-24558 or equal for each engine (existing terminal boxes maybe utilized),

The MCS shall pick up all signals for engine control and monitoring in the engine terminal boxes. Or if the new engine is supplied with an electronic engine control unit and an electronic engine monitoring unit, these units shall interface to the MCS as well as a Local Operating Panel (LOP). [v11]

3.233 <u>Main Propulsion Diesel Engines</u>

3.233.1 Definitions.

a) Main Propulsion Diesel Engine (MPDE) – Defined as the prime mover of the ship.
b) Auxiliary systems – Those systems not directly attached to or provided with the diesel engine but servicing the diesel engine.
c) Attached components – Those components mechanically attached and driven by the diesel engine.

3.233.2 General Requirements. Replacement engines shall meet the requirements of the Technical Specification for MPDE and SSDG Engine Retrofit Application for MHC-51 and MCM-1 Class Ships. The following are performance requirements for the replacement of MPDEs not specifically addressed by that specification.

3.233.3 Components. MPDE Components shall be in accordance with Technical Specification for MPDE and SSDG Engine Retrofit Application for MHC-51 and MCM-1 Class Ships. Components directly attached to the new diesel engines shall meet the requirements outlined for components used in the auxiliary systems to which they interface. All new components installed serving any one engine shall be 100% interchangeable with those installed on the other engines. New interface components shall not affect existing system reliability and maintainability. All new interface components shall meet design limits of the specific system they occupy while supplying the needs of the system. Equipment shall meet shock requirements of Section 3.072.

3.256 <u>Seawater Cooling System</u>

3.256.1 Definitions.

a) ASW – Auxiliary Seawater
b) DGSW – Diesel Generator Seawater
c) MSW – Main Seawater

3.256.2 General Requirements. Following are performance requirements for seawater cooling. The existing ship's system shall be reconfigured to accommodate engine replacements. Reconfigured diesel engine seawater cooling system shall be capable of delivering seawater to each installed diesel engine via its attached pump, provide sufficient cooling of engine jacket water and be discharged overboard. MCM1 and MCM2 currently require cooling to fuel oil coolers in addition to the Jacket water coolers. System shall be insulated per Section 3.508. System shall meet shock requirements of Section 3.072. System shall meet requirements of Section 3.505 and as follows.

3.256.3 Arrangement. Piping arrangement shall ensure that all heat exchangers are fully flooded under all operating conditions. An emergency supply of seawater shall be provided from the auxiliary seawater cooling main to each diesel.

3.256.3.1 MCM1 through MCM14 Reconfiguration Boundary. Removal and modification of seawater cooling system shall be limited as follows:

a) Main Propulsion Diesel Seawater Supply – From the existing engine connections to a point no further upstream than the two suction isolation valves for MSW and ASW. See Figure 1.
b) Main Propulsion Diesel Seawater Discharge – From the existing engine connections to the MSW discharge isolation valve. See Figure 2 for MCM1 and 2. See Figure 3 for MCM3 through MCM14.
c) Ship Service Diesel Generator Seawater Supply – From the existing engine connections to a point no further upstream than the two suction isolation valves for DGSW and ASW. See Figure 1.
d) Ship Service Diesel Generator Seawater Discharge – From the existing engine connections to a point no further downstream than DGSW discharge isolation valve. See Figure 1.

3.256.3.2 MCM1 and MCM2 Interface. Reconfigured seawater system shall interface with existing ships system as follows:

a) Main Propulsion Diesel Seawater Supply – 4” nps gate valve outlet, 150 pound Navy flange.
b) Main Propulsion Diesel Seawater Discharge – 4” nps gate valve outlet, 150 pound Navy flange.
c) Ship Service Diesel Generator DGSW Supply AMR (2) – 5” nps gate valve outlet, 150 pound Navy flange.
d) Ship Service Diesel Generator DGSW Supply MMR (1) – 4” nps gate valve outlet, 150 pound Navy flange.
e) Ship Service Diesel Generator ASW Supply – 3” nps gate valve outlet, 150 pound Navy flange.
f) Ship Service Diesel Generator Seawater Discharge – 4” nps gate valve outlet, 150 pound Navy flange.

3.256.3.3 MCM3 through MCM14 Interface. Reconfigured seawater system shall interface with existing ships system as follows:

a) Main Propulsion Diesel Seawater MSW Supply – 4” nps gate valve outlet, 150 pound Navy flange.
b) Main Propulsion Diesel Seawater ASW Supply – 3” nps gate valve outlet, 150 pound Navy flange.
c) Ship Service Diesel Generator Seawater DGSW Supply – 3” nps gate valve outlet, 150 pound Navy flange.
d) Ship Service Diesel Generator Seawater ASW Supply – 3” nps gate valve outlet, 150 pound Navy flange.
e) Ship Service Diesel Generator Seawater Discharge – 3” nps gate valve outlet, 150 pound Navy flange.

3.256.4 Components. All components and material used in seawater cooling system shall be capable of continuous operation within system design temperatures and pressures of 99 degrees F (37 degrees C) at 40 psig (276 kPa).

3.256.4.1 Valves and Components. High points in piping or equipment where air could accumulate shall have a local means of venting or removing air. Valve construction, except where otherwise permitted by Government specifications and Standard Drawings referenced in MIL-STD-777, shall be as follows:

a) Valve-operating threads shall be external to the fluid boundary;
b) Gate valves shall have stems of one-piece construction and the disc shall not be pinned to the stem.

3.256.4.2 Strainers. If existing system strainers do not meet manufacturer's specification for particle size removal, new strainers shall be installed in the reconfigured seawater piping for each engine.

3.256.5 Operation. Following operational conditions shall be demonstrated by formal engineering calculations in accordance with Section 3.505.

3.256.5.1 Flow. Reconfigured piping system shall meet the existing seawater cooling system capacities of 132 gpm (500 lpm) (minimum) to main propulsion engine and ship service generator engine at 99 degrees F (37 degrees C) when operating at full power. Reconfigured seawater cooling piping system shall not exceed the fluid velocity limits of Section 3.505.

3.256.5.1.1 Where automatic flow regulating valves are not provided integral to the engine assembly, a manually operated throttling valve shall be provided in the seawater discharge from the engine assembly. Heat exchangers shall be protected from excessive seawater flow in the event of a fully open manual or automatic (fail-open type) seawater cutout or throttle valve. If the design of seawater piping serving heat exchangers does not inherently limit seawater flow to the velocities specified in Section 3.505 or the applicable heat exchanger flowrate specification, whichever is less, a flow limiting orifice shall be provided in the heat exchanger seawater outlet piping to limit the flow. Fail-closed type valves having a manual override device shall be treated as fail-open type for purposes of this requirement.

3.256.5.2 Pressure Requirements. System shall be designed to provide a positive suction head to the attached seawater pump.

3.256.6 Quality Assurance and Cleaning Requirements. The seawater system shall meet the cleanliness and testing criteria specified in Sections 3.505 and 3.095, respectively.

3.259 <u>Combustion Air and Exhaust System</u>

3.259.1 General Requirements. Following are performance requirements for combustion air and exhaust system. The existing ship's system shall be reconfigured to accommodate engine replacements. Diesel engine combustion air system shall deliver clean air independently to each installed diesel engine for combustion. Diesel exhaust system shall safely remove exhaust gases independently from each engine after combustion and deliver to the weather. Noise produced during system operation shall not exceed the levels defined in Section 3.073. Combustion air and exhaust systems shall be airtight. System shall meet shock requirements of Section 3.072. System shall meet requirements of Section 3.505 and as follows.

3.259.2 Arrangement.

3.259.2.1 MCM3 through MCM14 Reconfiguration Boundary. Reconfiguration of system shall be limited as follows:

a) Combustion Air – From the existing engine connection to a point no further than the engine compartment penetration at the main deck. For MPDE boundary see Figure 7. For SSDG boundary see Figures 8 and 9.
b) Exhaust – From the existing engine exhaust manifold to the inlet flange of the muffler. For MPDE boundary see Figure 11. For SSDG boundary see Figures 8 and 9.
c) Low point drains – From the low point connection to the terminus of the drain piping above applicable oily waste drain collection system funnel. See Figures 8, 9, and 11.

3.259.2.2 MCM3 through MCM14 Interface. If system is reconfigured to above limits, interface is as follows:

a) Main Propulsion and Ship Service Diesel Generator Diesel Combustion Air – 8” nps tubing, CRES 304, schedule 10.
b) Main Propulsion and Ship Service Diesel Generator Diesel Exhaust – 10” nps flat faced flange, bolting per ASME B16.5, 150 psi

3.259.2.3 MCM1 and MCM2 Reconfiguration Boundary. Reconfiguration of system shall be limited as follows:

a) Combustion Air – From the existing engine connection to a point no further than the engine compartment penetration at the main deck. For MPDE boundary see Figure 4. For SSDG boundary see Figures 5 and 6.
b) Exhaust – From the existing engine exhaust manifold to the terminus of the exhaust piping (note, existing CRES 316L exhaust tubing cannot meet temperature performance requirements of 3.259.3.1.b). Muffler shall be retained. For SSDG boundary see Figures 5 and 6.
c) Low point drains – From the low point connection to the terminus of the drain piping above applicable oily waste drain collection system funnel. See Figures 5, 6, and 10.

3.259.2.4 MCM1 and MCM2 Interface. If system is reconfigured to above limits, Interface is as follows:

a) Main Propulsion and Ship Service Diesel Generator Diesel Combustion Air – 8” nps tubing, CRES 304, schedule 10.
b) Main Propulsion and Ship Service Diesel Generator Diesel Exhaust – Inlet and outlet of existing muffler, 10” nps flat faced flange, bolting per ASME B16.5, 150 psi

3.259.2.5 MCM1 through MCM14 Crankcase Fume Vent. See Technical Specification, Main Propulsion and Ship Service Diesel Engine Retrofit Application for MHC51 and MCM1 Class Ships section 2.5.2, Crankcase Fumes.

3.259.3 Components.

3.259.3.1 General. All components installed serving any one engine shall be 100% interchangeable with those installed on the other engines. All components and material used in combustion air and exhaust systems shall be capable of operating in the system design temperatures and pressures as follows:

a) Combustion air – 150 degrees F (66 degrees C), atmospheric pressure
b) Exhaust – 1,040 degrees F (560 degrees C), atmospheric pressure

3.259.3.2 Flexible Pipe Elements. Reconfigured exhaust system shall contain flexible pipe elements that allow for movement of the system due to thermal expansion during all operating conditions. As a minimum, flexible pipe elements shall be installed where combustion air and exhaust systems are connected to each engine to prevent engine vibration passing to the systems. They may also be required at other locations to accommodate system thermal movements as discussed in 3.259.4.1.

3.259.3.3 Pipe Supports. Supporting elements shall be in accordance with Section 3.505.

3.259.3.4 Clean Outs. Reconfigured combustion air system shall contain sufficient removable cover openings for inspection and clean out purposes.

3.259.3.5 Low Point Drains. Low points shall be minimized, but where unavoidable, reconfigured combustion air and exhaust systems shall contain low point drains with isolation valves for removal of condensation. Low point drains from SSDG system shall be led to existing overboard discharge connection. Drains from MPDE system shall be led to bilge.

3.259.3.6 Air Filters. Each engine shall have a combustion air system filter in accordance with the engine manufacturer's recommendation and comply with "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships".

3.259.3.7 Joints. Minimum number of mechanical joints shall exist in the reconfigured system to allow engines to be removed and installed as defined in Technical Specification, Main Propulsion and Ship Service Diesel Engine Retrofit Application for MHC51 and MCM1 Class Ships. Flange joint assemblies shall compress gasket material to the gasket manufacture's recommended value without loading fasteners beyond I of their yield value, as demonstrated by formal calculations in accordance with Section 3.505. Gasket compression shall be maintained during all thermal cycles of engine operation. Welded joints in exhaust system shall comply with NAVSEA S9074-AQ-GIB-010/278 for P-1 joints.

3.259.3.8 Insulation. Insulation material shall be compatible with exhaust piping material at operating temperature. CRES piping shall be insulated with Calcium Silicate per MIL-I-24244, Type 1. See Section 3.508 for general insulation requirements.

3.259.4 Structural Requirements. Reconfigured combustion air and exhaust system stress exerted upon flexible connections, expansion joints and support structure shall conform to Section 3.505 during all operating and non-operating conditions. Engine vibrations shall not be transmitted through the reconfigured system's support structure that exceed those specified in Section 3.073. The system shall withstand induced stresses of weight, thermal expansion, engine vibration, working of the ship, and pressure thrust caused by combustion air and exhaust gas.

3.259.4.1 Flexibility. Reconfigured exhaust system shall have sufficient flexibility to allow for repeated thermal expansion of the entire system during all operating and non-operating conditions. System flexibility shall be demonstrated by formal engineering calculations in accordance with Section 3.505.

3.259.5 Operation.

3.259.5.1 Flow. Reconfigured combustion air system shall meet the existing system capacities of 1,841 cfm (52.13 cmm) of air at 150 degrees F (66 degrees C) to each main propulsion diesel, and ship service diesel when at full power. Reconfigured exhaust system shall meet the existing system capacities of 4,002 cfm (113.3 cmm) at 1,040 degrees F (560 degrees C) from each main propulsion diesel, and ship service diesel when at full power. These flow conditions shall be demonstrated by formal engineering calculations in accordance with Section 3.505.

3.259.5.2 Pressure Requirements. During all engine operating conditions, reconfigured combustion air system shall meet the existing vacuum parameters of **15.0** inches (**38.1** cm) of water for main propulsion diesels, and ship service diesels. With blockage of the normal air passage, air from the engine or generator rooms shall enter the combustion system to support rated engine load permitting uninterrupted operation of the engines and an alarm shall activate as specified in Section 3.202. Reconfigured system shall not subject MPDE and SSDGs to a backpressure greater than that specified in Technical Specification, Main Propulsion and Ship Service Diesel Engine Retrofit Application for MHC51 and MCM1 Class Ships. This shall be demonstrated by formal engineering calculations in accordance with Section 3.505.

3.259.6 Quality Assurance and Cleaning Requirements. The combustion air and exhaust systems shall meet the cleanliness and testing criteria specified in Sections 3.095 and 3.505, respectively.

3.262 <u>Lube Oil System</u>

3.262.1 The lube oil and fill transfer system shall meet the existing tank capacity based on filling one MPDE and three SSDG engines plus a five day allowance for engine consumption. The lube oil service system shall be provided with a fill connection for filling engine sumps with clean lube oil and a separate connection for removing dirty lube oil. A lube oil service system sampling connection shall be provided external to any acoustic enclosure.

3.300 <u>Electric Plant, General</u>

3.300.1 Definitions.

a) Electric plant. - Consists of the generator, SSDG engine, and distribution system with supporting piping, electrical, and control systems required for the ship.
b) Ship Service Diesel Generator (SSDG) Engine. - The energy source used to drive the generator.
c) Subbase. - In a resiliently mounted configuration, the stiff structural platform on which the isolated machinery is rigidly mounted.

3.300.2 General Requirements. A replacement SSDG engine shall be provided per "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships."

3.300.2.1 Interface. The installed SSDG engine shall interface and operate with the following existing components:

c) Subbase assembly
d) Generator input shaft

3.300.2.1 Gears. Numbers of teeth on contractor furnished meshing elements (if part of proposed design) shall have no common factors.

3.300.2.2 Alignment. Correct alignment shall be maintained between the components of the generator unit in accordance with the engine manufacturer's specifications.

3.300.2.2.1 Chocks. Self-leveling, corrosion resistant steel, height adjustable chocks in sufficient quantity shall be used to maintain proper alignment of the diesel engine mounting system. Chocks shall withstand loads imposed by the weight of the engine and ship's motions as well as mechanical vibration.

3.300.2.2.2 Shims. Shims shall not be used with adjustable chocks.

3.300.4 Mounting System.. The engine mounting system shall meet airborne noise, radiated noise and sonar self-noise requirements specified in Section 3.073. New resilient mounts are required in accordance with Section 3.073.

3.300.4.1 All systems and components of the electric plant, including the SSDG shall meet shock requirements of Section 3.072.

3.300.4.2 The engine shall be hard mounted to the existing subbase. The mounting system shall be compatible with the existing subbase system (including resilient mounts below the subbase, and excursion snubber system).

3.300.4.3 The quantity and location of the new resilient mounts below the subbase shall be such that each mount is loaded within its rated capacity and that sound shorts shall not occur under the dynamic loading of moderate sea conditions as defined in Section 3.070. This does not apply to sound shorts during shock excursion at which time the subbase movement shall be restricted by shock excursion snubbers; however, the subbase shall return to the resilient mount supported position, and the propulsion units shall continue to operate without sound shorts.

3.300.4.4 Emergency Shut Down Device. The emergency shutdown device from the engine shall be connected to the existing pull cable system which can be operated from both the engine and a remote location, which shall secure flow to the injectors , shut off the air, and stop the engine without any damage within 60 seconds.

3.300.5 Electrical Cabling Requirements. Electrical cabling shall conform to the requirements of Section 3.304. Remove existing cabling from equipment to be removed to the first junction (e.g. connection box, electrical panel, controller).

3.300.5.1 New cabling and equipment shall be marked and designated in accordance with Section 3.305.

3.300.6 MPDE Electric Power Interface. The new MPDEs shall interface with the existing electrical power system as follows:

3.300.6.1 Engine jacket water pre-heater and thermostat shall interface with the existing controller (450VAC, 60 hz, 3 phase, 15 amps max; thermostat 120VAC, 60 hz, 1 phase).

3.300.6.2 Engine lube oil pre-heater and thermostat shall interface with the existing controller (heater 450VAC, 60 hz, 3 phase, 15 amps max; thermostat 120VAC, 60 hz, 1 phase).

3.300.6.3 The engine speed control system shall interface with the MCS. Engine loading shall be balanced between engines for two engine per shaft operations.

3.300.7 SSDG Electric Power Interface. The new SSDGEs shall interface with the existing electrical power system as detailed in Section 3.310.

3.304 <u>Electrical Cable</u>

3.304.1 New electrical power cables installed shall be unarmored low smoke type, conforming to MIL-C-24640 (Lightweight) or MIL-C-24643 and as follows.

3.304.1.1 Cable amperage capacity shall be at least equal to the resultant load current and exceed the rating of the protective device for the circuit.

3.304.1.2 Solderless type ring lug terminals shall be used for all applications, except for equipment having solder type terminals provided by the manufacturer.

3.304.1.3 NAVSEA standard methods of installation per DOD-STD-2003, ELECTRIC PLANT INSTALLATION STANDARD METHODS, shall be used for the following:

a) Cable end sealing.
b) Cable entering wiring boxes or equipment.
c) Cable splicing and repair.
d) Preparation of cable ends.
e) Protection of cables against heat, condensation, moisture, and mechanical damage.
f) Supporting cables and securing cables to decks and bulkheads.

3.305 <u>Electrical and Electronic Designating and Marking</u>

3.305.1 Definitions.

a) Tag - A label bearing identification or data pertinent to the item to which it is attached.
b) Identification plate - A plate installed by a manufacturer on his machinery or equipment that bears essential identification data.
c) Information plate - A plate that bears essential warning, operating, and maintenance instructions. An information plate may be in any one of the following formats:
   1. Warning plate - A plate that bears essential precautionary information, the ignoring of which might result in personal injury.
   2. Posted operating instruction - A plate or laminated sheet that displays a copy of operating instructions taken from the applicable system or equipment technical manual.

3. Posted diagram - A plate that displays a copy of a system or equipment diagram taken from the applicable system or equipment technical manual.
4. Reference data plates - A plate that displays frequently used and generally unchanging data that is useful to the operator, such as battery temperature/voltage/gases data, speed or depth limits for hardup thrust bearing operation, voltage or current limitations for the single phase motor, lubrication charts for lubrication systems.
5. Caution plate - A plate that bears essential precautioning information, which by ignoring, could result in damage to the equipment, systems, or adjacent structure.
6. Safety information may be included on applicable information plates.

d) Label plate - A plate that designates the component as part of a shipboard system, designates basic location number of a component, or provides other necessary identification or information in addition to that appearing on identification plates or information plates.

3.305.2 General. Identification of power, lighting, electronic, interior communication, and other electric equipment circuits and cables shall be the same as that used for the existing installation.

3.305.2.1 Information plates, label plates and tags shall be installed in readily visible locations on the equipment they identify or, if this is not practicable, on adjacent structure.

3.305.2.2 If the nomenclature of equipment or cables follows a numerical or alphabetical series and the series is broken by deletions, remaining equipment need not be renumbered.

3.305.2.3 Color-coding of new cables shall be compatible with that of existing cables and wiring, where there is no conflict with this section.

3.305.3 Numbering of Equipment. Except as otherwise specified herein, the following method shall be used for numbering electric machinery or similar equipment in a system:

3.305.3.1 All similar equipment in a system shall comprise a group, and each group shall be assigned a separate series of consecutive numbers, each series beginning with 1.

3.305.3.2 The number shall be assigned in the order that the equipment is added to the system.

3.305.3.3 If a modification to the system requires the removal of a piece of equipment from the system, its number shall not be reassigned.

3.305.4 Equipment Designation. All switchboard mounted apparatus shall have identification plates and information plates with information complying with MIL-S-16036.

3.305.4.1 Distribution panels shall have circuit information plates adjacent to the handle of each circuit breaker or switch; information in the following order:

a) Circuit number.
b) Name of apparatus or circuit controlled.
c) Location of apparatus or space served.

3.305.4.2 Cables and conductors on switchboards and panels shall be marked near each terminal to identify the conductors with the terminals to which they are to be connected. The marking numbers or letters or combinations thereof shall be in agreement with those shown on approved wiring drawings.

3.305.4.3 Fuse boxes - Information plates shall be provided on or in boxes, for each set of fuses, and shall indicate the circuit controlled, the phases or polarities, and the fuse ampere ratings.

3.305.4.4 Controllers shall have each terminal marked with standard designations in accordance with MIL-STD-195. Such markings shall be accomplished by one of the following methods:

a) Information plates adjacent to terminal studs.
b) Stamping on terminals.

3.305.5 Cable and Conductor Identification.

3.305.5.1 All permanently installed cables shall be tagged, as close as practicable, to each point of connection, and on both sides of decks and bulkheads except as follows:

3.505.5.1.1 Where through cable runs within a compartment are direct (such as a vertical run between decks), a single tag shall suffice. Cables with both points of connection within a compartment and which can be readily traced, a single tag shall suffice.

3.305.5.2 Where compartments are subdivided by internal bulkheads or where machinery or installed equipment makes tracing of cable runs difficult, additional tags shall be provided.

3.305.5.3 Power and lighting cables. The designation of power and lighting cables shall consist of four parts in sequence separated by hyphens: source, voltage, service, and destination. In lieu of the destination, an alpha or alphanumeric designator shall be substituted for cables connected to distribution boxes and for cables supplying power-consuming equipment.

3.305.5.4 Cables with alpha or alphanumeric designators. Cables to power consuming equipment shall receive a single letter designator, beginning with A and progressing through the alphabet for each succeeding piece of power consuming equipment supplied from the same distribution. The designator for cables connected to distribution boxes shall consist of alternately, a letter, a number, a letter and a number, progressively every time that it is fused. The designator shall not be changed on single circuits that branch from a terminal box or fixture, although a suffix number in parenthesis indicating the cable section shall be added to the designator.

3.305.5.5 Cable service designation. The following letters shall be used to designate the various cable services:

Service	Designation
Control, power plant and ship	K
Electronics	R
Interior communications	C
Lighting, ship service	L
Lighting, emergency	EL
Power, ship service	P
Power, emergency	EP
Power, special frequency	SF

Degaussing	D

3.305.5.6 The numbers used to designate voltage shall comply with the following:

Volts	
0 – 99	See note 1
100 - 199	1
200 - 299	2
300 - 399	3
400 - 499	4

NOTES:
1. Voltages below 100 V shall be designated by the actual voltage, for example, 24 for a 24-volt circuit.

3.305.5.7 Examples of typical power and lighting cable designations are given as follows: (Power shown. Substitute "L" for "P" for lighting)

Cable Name Designation	**Remarks**
Feeder:	
1S-4P-(1-21-1)	450 Volt feeder from Switchboard 1S.
Main:	
(1-21-1)-4P-A	
Submain:	
(1-21-1)-4P-A1	
Branch:	
(1-21-1)-4P-A1A	
Sub-branch:	
(1-21-1)-4P-A1A2	

Component parts of the above examples indicate the following:

Component	**Meaning**
1S-4P	450 Volt power from ship service switchboard 1S
(1-21-1)	Power Distribution Panel located on 1st deck, frame 21, starboard side of centerline.
A	No. 2 feeder, main, or submain supplied from load center switchboard or distribution panel.
A1	No. 1 submain or branch supplied from distribution panel or distribution box.
A1A	No. 1 branch or sub-branch supplied from distribution box.
A1A2	No. 2 sub-branch supplied from distribution box.

3.305.5.8 Each conductor shall be marked at each end to identify the conductor. The markings shall consist of a number assigned to each connection point the schematic or elementary diagram starting with 101. All conductors emanating from a connection point shall retain the number of that point until they terminate. Connection points that are common to each other shall bear the same number. Spare conductors and terminals shall be unmarked.

3.305.5.9 Control Circuit Designations:

1.1 Designation	Service
K-SG	Ship service generator control and indication.
K-EC	Electric Plant control

3.305.5.10 If two or more systems are installed that shall require identical designating letters, differentiating numbers in sequence must be used. For example, K-1SGA; ship service generator no. 1. Unit A; K-2SG; ship service generator no. 2.

3.305.5.11 A number shall be assigned to each cable on the ship's installed cables and on ship's system schematic or elementary diagram, starting with 1.

3.305.5.12 The following are examples of the above method of cable numbering:

Example: K-1 SG A 5
b b b bb
b b b bƈƅƅƅ Fifth cable in circuit
b b b b
b b b ƈƅƅƅƅ Service unit number
b b b
b b ƈƅƅƅƅƅƅ Service
b b
b ƈƅƅƅƅƅƅƅƅ Service number
b
ƈƅƅƅƅƅƅƅƅƅ Service Designation

3.305.5.13 Conductors in control system cables shall be marked at each end. These markings shall consist of the number and letter combination, to identify the circuit, followed by a number to be determined as follows:

3.305.5.13.1 A number starting with 101 shall be assigned to each connection point on the ship system schematic or elementary diagram. All conductors emanating from a connection point shall retain the number of that point until they terminate at a terminal board or an appliance, such as a switch, fuse, relay, disconnect or indicator light. Drawings shall show the changeover (such as provided by a terminal board) from the ship numbering to the numbering system of the equipment wiring as provided by the equipment manufacturer. Each cable conductor shall be identified on each side of the changeover point, both on the drawing and on the installed cable, in order that identification may be followed from one numbering system to the other.

3.305.5.13.2 Common connection points and the conductors between them shall all bear the same number.

3.305.5.13.3 The following is an example of the above method of conductor numbering:

Example: K-1 SG A 120
b b b b b
b b b b ƈƅƅƅ Conductor emanates from connection 120
b b b b
b b b ƈƅƅƅƅ Service unit number
b b b
b b ƈƅƅƅƅƅƅ Service
b b

ɓ ƈƅƅƅƅƅƅƅƅ Service number
ɓ
ƈƅƅƅƅƅƅƅƅƅ Service Designation

3.305.6 Color Designation.

3.305.6.1 Indicator lights. Color designation, except for special applications in dark adapted spaces and for ground detector lights, shall be in accordance with MIL-STD-1472.

3.305.6.2 Conductor color coding. Color coding of the individual conductors of multiconductor cables shall comply with MIL-C-24643.

3.305.7 Identification Plates and Cable Tags. Identification plates shall comply with MIL-P-15024 and the applicable equipment specifications.

3.305.7.1 Abbreviations used on information plates and label plates shall comply with ANSI/IEEE 260.1 and ASME Y14.38.

3.305.7.2 Tags and strips for marking cables shall be of soft aluminum tape per MIL-A-2877, having a natural finish, except where used with cables having bronze armor, in which cases sheet brass of commercial quality shall be used.

3.305.7.3 Dimensions. Identification plates, information plates, and label plates shall be of a size suitable for the equipment on which installed and shall be one of the sizes listed in MIL-P-15024.

3.305.7.4 Identification plates for rheostat handwheels and other rotary switches may be circular, or other shape to suit the equipment.

3.305.7.5 Cable tags shall be of size suitable to accommodate the required marking but shall have a minimum width of 1/2 inch.

3.305.7.6 Type and size of lettering. Type and size of lettering for identification plates shall comply with MIL-P-15024. If abbreviations are necessary, apostrophes, periods, and other suitable punctuation marks shall be used to clarify the meaning.

3.305.7.7 Capital letters shall be used on cable tags; height of all letters and numbers shall not be less than 3/16 inch, and letters and numbers, shall be embossed to at least 1/64 inch above the surface.

3.305.7.8 Installation. Installation of identification plates and information plates shall comply with MIL-P-15024.

3.305.8 Conductor Marking. Individual conductors shall be marked by one of the following methods:

a) Heat-shrinkable tubing with the markings permanently bonded to the tubing by a heating process. The tubing shall be in accordance with SAE AMS-I-23053/2.
b) Hot stamping (branding) insulating sleeving. Sleeving shall be in accordance with MIL-I-631, type F, grade A, form U, white.

3.305.8.1 Conductors terminating in pin-type connectors need not be marked at the connector end.

3.310 Electric Power Generation

3.310.1 General Requirements. Replacement engines shall meet the requirements of the Technical Specification for MPDE and SSDG Engine Retrofit Application for MHC-51 and MCM-1 Class Ships. The following are performance requirements for the replacement of the SSDG engines not specifically addressed by that specification.

3.310.1.1 Remove existing cabling from equipment to be removed to the first junction (e.g. connection box, electrical panel, controller).

3.310.2 Interface

3.310.2. 1 The engine shall mechanically interface with the existing 375 KW Tech Systems (Ward Leonard) type 760R10.1 generator (S9311-CF-MMO-010) via a torsional/flex-type coupling that shall compensate for small misalignments. The coupling must transmit power from the engine to the generator as described in Section 3.310.6.1 without suffering damage.

3.310. 2.2 The engine shall interface with the MCS and switchboard Controls and in addition, shall provide means for electronic load sharing,speed control and speed indication. The speed sensing circuit shall not be affected by disturbance in the voltage of the generator. Speed sensing shall not be lost when generator output voltage is reduced to zero. The switchboard controls include engine prelube pump start/stop, engine speed raise/lower, engine start/stop and isochronous/droop control mode.

3.310.3.2.5 The local diesel control panel shall contain a switch for maintenance lockout of the generator space heaters (120VAC, 60 hz, 4A, 1 ph). This criteria will add a feature that does not currently exist.

3.310.4 Components.

3.310.4.1 General. Components directly attached to the new diesel engines shall meet the requirements outlined for components used in the auxiliary systems to which they interface. New interface components shall not adversely affect existing system reliability and maintainability. All new interface components shall meet design limits of the specific system they occupy while supplying the needs of the system. Equipment shall meet shock requirements of Section 3.072.

3.310.5 Performance Requirements.

3.310.5.1 The diesel engine shall be rated for continuous operation at 1800 rpm while driving the generator at rated load of 375 KW at 450 VAC and 0.8 lagging power factor.

3.310.5.2 The diesel engine shall be capable of providing 110% overload capacity (330 KW at 0.8 lagging power factor) for two hours.

3.310.5.3 The diesel engine shall be capable of providing 150% overload capacity (450 KW at 0.8 lagging power factor) for two minutes.

3.310.5.4 The maximum permissible overspeed or underspeed upon application or removal of 90% rated KW load shall be 5.5% of rated speed. Based on a prescribed speed band of 1.0% (+/- .5%), the recovery time shall not exceed 2 seconds.

3.310.5.5 The speed control system shall regulate the speed within a steady state band of +/- .25% for any load between 0 and 100%.

3.310.5.6 In the event of the failure of any electronic part, the loss of governor actuator voltage if equipped, or the loss of the generator output voltage, the speed control system shall prevent the generator set from reaching 115% of rated speed.

3.310.5.7 The speed adjustment range shall be from 33% to 116% of rated speed. Normal speed range stops shall be set for 95 to 105% of rated speed.

3.310.5.8 When placed in parallel operation, at any load between 20 and 100%, the engine load sharing system shall maintain load division within 5%. This time required for the load division to become stable shall not exceed 5.0 seconds.

3.310.5.9 Engine crankshaft rotation shall be counter-clockwise as viewed from the main drive end (flywheel end).

3.310.5.10 New equipment shall meet shock requirements of Section 3.072.

3.310.6 MCM 1 and 2 only. MCM 1 and 2 have electric pre-lube pump motors vice air operated motors as the rest of the class. If pre-lube pump motors other than electric are supplied, remove the existing system up to the power panel.

3.320 <u>General Requirements for Electric Power Distribution System</u>

3.320.1 General. Testing of the Electric Power Distribution System is required only to the extent necessary to verify proper operation of newly installed systems or systems disturbed or modified.

3.320.2 Testing Requirements. Insulation resistance test of new/disturbed cables in accordance with section 3.095.320.

3.320.2.1 Operational testing shall be performed to verify that each system performs its designed function.

3.406 <u>Electromagnetic Interference (EMI) Reduction</u>

3.406.1 General Requirements. Electrical and electronic equipment and interconnecting cable shall meet and be installed in accordance with the EMI reduction requirements of MIL-STD-461E.

3.406.2 Equipment. New and/or modified electrical and electronic equipment shall be grounded in accordance with the EMI reduction requirements of the most current revision of MIL-STD-1310.

3.406.3 Cable Shielding. Cable, wire or conduit shielding shall be single point grounded at the input of the terminating equipment or equipment rack on an exterior metallic point, except for sensitive signal cables which shall be grounded at both ends (direct ground at one end, and through a .1 micro Farad capacitor at the other end). Cable, wire or conduit shielding shall not transit into, or be grounded into, the outermost metallic enclosure of the terminating equipment.

3.406.3.1 Junction boxes shall be metallic and grounded. Cables from equipments to junction boxes shall be single point grounded at the junction box.

3.406.4 Cable Ground System. A cable ground system is installed in accordance with MIL-STD-1310. Electrical and electronic equipment and metallic items shall be single point grounded to the cable grounding system as specified in MIL-STD 1310. Additionally, branch ground wires for engines shall be single point grounded with 83,690 circular mil cable.

3.475 Degaussing System Performance

3.475.1 MCM Degaussed Limit. No changes in the degaussing system are required for the MCM Ship. However, the overall ship degaussing performance must be guaranteed. The MCM Degaussing system shall be capable of degaussing the ship in a Navy approved magnetic silencing facility (MSF) to less than 50% of the MCM check range limit.

3.504 Instruments and Instrument Boards

3.504.1 General Requirements. The existing instrumentation and associated boards shall be removed to accommodate engine replacements. Removal shall include tubing, hoses, valves, cabling, and associated components from engine connections to instruments. Instrument board and instruments and its associated foundation shall also be removed. New engines shall be supplied with local instrumentation in accordance with the Technical Specification for MPDE and SSDG Engine Retrofit Application for MHC51 and MCM1 Class Ships. All removed valves and instruments shall be turned over to local item manager for disposition.

3.505 General Requirements for Piping Systems

3.505.1 Definitions

a) Damage Control Valve – A valve with one or more of the following assigned functions:
   1. Preventing progressive flooding between main watertight subdivisions.
   2. Isolating machinery, equipment or sections of piping systems in the event of casualty or damage to the machinery, equipment or section of the system. These valves may be operable from local and remote stations, or they may consist of two valves in a machinery plant system on opposite sides of a watertight boundary. In this regard, the valves serve the same function as valves commonly referred to as casualty control valves. The primary purpose is to minimize the effect of loss of machinery plant, vice performing the function of maintaining watertight integrity, or providing a material condition of readiness for a specific system.
   3. Providing segregation of portions of systems, during normal operation of the ship, to achieve material conditions of readiness.
b) Flammable Fluid – Any fluid that can be ignited by application of a flame or otherwise ignited under atmospheric conditions.
c) Hazardous Fluid – Any gas or liquid on the Hazardous Material Identification System (HMIS).
d) Maximum Operating Pressure – The highest pressure that can exist in a system or subsystem under normal operating conditions. This pressure is determined by such influences as pump or compressor shutoff pressures, pressure

regulating valve lockup (no-flow) pressure, and maximum chosen pressure at the system source.

e) Maximum System Pressure – The highest pressure that can exist in a system or subsystem during any condition. Normal, abnormal and emergency operation and casualty conditions shall be considered in determining the maximum system pressure. In any system or subsystem with relief valve protection, the nominal setting of the relief valve, as described in the subparagraph covering relief valve setting and installation in this section, shall be taken as the maximum system pressure (relief valve accumulation may be ignored).

f) Maximum System Temperature – The highest temperature that can exist in a system or subsystem during any operation. Normal, abnormal, and emergency and casualty conditions shall be considered in determining the maximum system temperature.

g) Nominal Operating Pressure – The approximate pressure at which an essentially constant pressure system operates when performing its normal function. This pressure is used for the system basic pressure identification.

h) Nominal Operating Temperature – The approximate temperature at which an essentially constant temperature system operates when performing its normal function.

i) System Design Pressure – The pressure used in the calculation of piping and piping components minimum section thicknesses. Unless otherwise specified herein, the design pressure shall not be less than the maximum system pressure.

j) Vital System – A piping system, or that portion thereof, whose continual operation is essential for maintaining ship's control, propulsion, communications, seaworthiness, damage control and fighting capability, or is required to meet Grade A shock capabilities.

3.505.2 System Design Requirements. As a result of engine replacement, reconfigured piping systems and components shall perform as described in this section. Performance requirements peculiar or supplemental to a specific system are covered by the section governing that system. Where supplemental or differing requirements are specified in the section governing the system, the system section requirements take precedence. As a minimum, each reconfigured system shall have the same capabilities as was present prior to engine replacement, except as modified herein and in the applicable system section.

3.505.2.1 Flow Calculations. Flow calculations shall be prepared for each system to ensure that the system shall be designed for maximum efficiency (taking into consideration such items as system weight and power consumption) and that flow, pressure, and operating requirements shall be satisfied. Each set of calculations shall clearly indicate all criteria, assumptions and methods used to arrive at the system design. Documents (such as textbooks, technical papers or professional codes) used as guides in the preparation of the calculations, or for obtaining formulae, shall be referenced. The flows, pressures and temperatures associated with each mode of intended system operation (for example, the filling and transfer modes of a fuel system) shall be clearly indicated. The applicable system diagram shall also be referenced.

3.505.2.2 Environmental Conditions. Reconfigured piping and piping components shall operate satisfactorily under the following conditions:

a) External Climatic – Where installed in exposed locations under the climatic conditions specified in Section 3.070.

b) Ship Motion – Where the ship motions of trim, list, pitching and rolling is as specified in Section 3.070.

c) Ambient Pressure – Over a range of ambient pressure variations from 14 psi (95 kPa) to 16 psi (110 kPa) absolute.
d) Ambient Temperature – Under the ambient temperature of 150 degrees F (66 degrees C).

3.505.2.3 Velocity Limits. Unless otherwise specified, the velocity in piping systems shall be based on the following:

a) Fluid velocity shall meet the minimum required inlet pressures of machinery, equipment and components under the maximum required flow conditions.
b) Fluid velocity shall meet the inlet velocity limitations of installed machinery, equipment and components.

3.505.2.3.1 Seawater system free-stream velocity shall not exceed 7½ ft/sec (2.29 m/sec) maximum at the inlet nozzles to heat exchangers. In addition, seawater free-stream velocity shall comply with the following for 90-10 Cu-Ni piping systems:

Outside Diameter (NPS)	Maximum (FT/SEC)	Velocity (M/SEC)
½	4.2	(1.28)
¾	4.8	(1.46)
1	5.4	(1.65)
1¼	6.2	(1.89)
1½	6.6	(2.01)
2	7.4	(2.26)
2½	8.2	(2.50)
3	9.1	(2.77)
3½	9.8	(2.99)
4	10.3	(3.14)
5	11.5	(3.51)
6 and larger	12.0	(3.66)

3.505.2.3.2 The minimum velocity is 3 ft/sec (0.91 m/sec) for pipe sizes up to 8 inches (20 cm) in diameter.

3.505.2.3.3 For 70:30 CuNi alloy, the above maximum velocity levels can be increased by 2 ft/sec (0.6 m/sec).

3.505.2.4 Corrosion and Erosion. Reconfigured seawater piping shall be protected from corrosion and erosion by utilizing the following system design criteria:

a) Minimizing flow turbulence by limiting free-stream velocities to specified maximum limits.
b) Eliminating abrupt changes of diameters in piping runs and connections.
c) The use of gradual transitions in diametrical changes where such changes cannot be eliminated.
d) Using long-radius elbows, sweep tees, and Y and lateral type fittings.

3.505.2.4.1 Components. Body passages in throttling devices shall provide for gradual changes in flow direction. In addition, the downstream cavity shall be as large as practical to permit dissipation of the issuing jet before making wall contact. At points where direct impingement at close range does occur and cannot be eliminated, section thickness shall be increased to provide adequate material to withstand the additional erosion effect.

3.505.2.4.2 Materials. Galvanic action between dissimilar materials shall be avoided by installation of waster pieces.

3.505.2.5 Equipment and System Isolation

3.505.2.5.1 Equipment Isolation. Machinery, equipment and piping components, except relief devices, shall be fitted with cutout valves as necessary to provide positive isolation for operation, maintenance and overhaul of the equipment.

3.505.2.5.2 System Isolation. Drain lines, test connections, pressure fill connections, and similar lines terminating to the atmosphere shall be provided with cutout valve for positive isolation from the atmosphere. If approved, plugs or caps may be used instead of valves in infrequently used applications where the plug or cap is accessible. Plugs and caps shall be tethered.

3.505.2.5.2.1 Check valves shall be installed to prevent reversal of flow detrimental to proper functioning of the system.

3.505.2.5.2.2 Double valve protection shall be provided for lube oil and fuel piping systems.

3.505.2.6 Remote Valve Operation. Where remote operation of valves is required and the type of operating system is not specified, a mechanical operating system shall be installed. Mechanical operating systems shall comply with NSTM S9086-RK-STM-010/Ch. 505.

3.505.2.6.1 Where the location of the operating terminal of remotely-operated valves has not been specified, accessible locations and spaces shall be selected, and shall not interfere with free passage in walking areas or form an obstruction in working areas.

3.505.3 Components: Design and Selection

3.505.3.1 Mechanically Attached Fittings (MAF). MAF may be used as an alternative to standard welded/brazed fittings in accordance with the requirements of Project Peculiar Document NAVSEA No. 802-6336823.

3.505.3.2 Valves. The following requirements apply to all valves, unless otherwise specified:

a) The design and dimensions shall conform to MIL-STD-777 subject to the magnetic material restrictions of Section 3.051.
b) End connections shall be as specified for the applicable service in MIL-STD-777 subject to the non-magnetic material requirements of Section 3.051.
c) Valves above ½ inch (13 mm) in size shall have the pressure rating, size, and manufacturer's name or trademark, cast or forged integral with the valve body. Where employed as a means of marking, metal stamping shall be permitted only on surfaces that are not subject to high stress in service. Where used, die stamps shall be of the round bottom type.
d) Valves ½ inch (13 mm) and below shall be fitted with an identification plate or tag securely attached to a part not subject to pressure. Where it is impractical to attach to a part other than a non-pressure part, attachment may be made on a low stress area or outer flange edge or identification can be made by the use of a metal photo band secured to the valve by a seal closure. The identification plate or tag shall contain the following information:
    1. Body material

2. Trim material (stem, disc and seat)
3. Manufacturer's drawing number
4. Temperature rating
5. CID number, if available at the time of tag manufacture, or space (nine digits) for future inscription (when available)
6. Set pressure (where applicable)
7. Attachment power requirements (where applicable)
8. Manufacturer's identification number

e) All stop-check valves shall have the word "CHECK" and an arrow indicating normal flow direction either cast on the side of the body of the valve (in addition to any other required marking), or stamped on a low stressed area, such as the edge of the valve bonnet flange or line flange.

3.505.3.2.1 All manually-operated valves, except push-pull and slide operated types, shall close with clockwise rotation of the handwheel. The maximum permissible handwheel seating force for manually-operated valves shall be in accordance with Table 505-1.

3.505.3.2.2 Handwheels having attached mechanical operating gear for damage control or casualty control shall be fabricated of CRES.

3.505.3.2.3 Valve Handwheels. Handwheels shall comply with Drawing No. 803-1385620.

3.505.3.2.3.1 Where commercial valves are permitted to be furnished with machinery and equipment, or in piping systems, handwheels normally furnished with these valves by the manufacturer are acceptable (except cast iron handwheels) instead of special Navy handwheels.

3.505.3.2.4 Valve Installation. Gate valves and ball valves shall not be installed for throttling services. Limitations on throttling of butterfly valves and system and service applications on the use of either resiliently seated or metal-to-metal seated butterfly valves are specified in MIL-STD-777.

3.505.3.2.4.1 Where the type of cutout valve is not specified, the type selected (gate, globe, ball, butterfly, or angle) shall be the one best suited for the service intended.

3.505.3.2.5 Position Indication. Where the valve construction does not provide indication, a valve position indicator shall be provided. For valves whose position is obvious for service intended, valve indicators are not required. Remotely operated valves shall also be provided with position indicators at all operating stations.

3.505.3.2.6 Locking Devices. Valves that could create a personnel hazard or endanger the safety of the ship due to inadvertent operation shall have a locking device or a protective enclosure. These devices shall be readily operable by authorized personnel but shall be sufficiently complex to discourage indiscriminate operation by others. Label plates shall be installed near locking devices to warn or instruct the operator, as applicable, wherever inadvertent operation of the valve can be detrimental. ASTM F993 depicts several acceptable types of locking devices.

3.505.3.3 Flexible Piping Devices. Flexible piping devices shall be used to connect sound isolated, resiliently-mounted machinery to piping. These devices shall consist of an assembly of flexible elements designed to absorb all possible modes and amplitudes of travel between machinery and piping. Flexible hose assemblies shall be in accordance with NAVSEA Publication No. S6430-AE-TED-010, Volume I.

3.505.3.3.1 Flexible Piping Device Calculations. Calculations are required to analyze all possible movements of the machinery both in normal operation and under conditions of high impact shock, and proof that the device shall accept such movements. The calculations shall include the following:

a) Identification of system and machinery.
b) A sketch showing all possible movements of the connection in the intended operating location.
c) Analysis of movements and associated stress calculations.
d) Flexible connection information, including:
   1. Vendor
   2. Material
   3. Fabrication
   4. Operating, design, and test pressures and temperatures
   5. Types of end connections

3.505.3.4 Pipe Supporting Elements. Supporting elements for reconfigured piping system shall be of sufficient quantity, location and design to support all loads transmitted from the system. Piping system loads shall encompass the weight of the piping, components, insulation, and system fluid.

3.505.3.4.1 Application of pipe supports shall also accommodate other load effects such as those introduced by maximum operating pressure, thermal expansion, shock, vibration and motion of the ship. Supporting elements shall be fabricated and assembled to permit the movement of piping caused by external forces or by thermal motion. The material selected for fabrication of pipe supports and hangers shall be determined by the environmental conditions to which it is subjected, such as, high humidity, moisture, or exposure to seawater.

3.505.3.4.2 Load calculations for constant supports shall be based on the maximum operating conditions of the system. They shall not include the weight of the hydrostatic test fluid. However, the supporting elements shall be capable of carrying the total load under test conditions.

3.505.3.4.3 Supports shall be installed on or adjacent to concentrated weights in the piping system to preclude contact with adjacent pipe, equipment, or structure under shock loading or under working of the ship.

3.505.3.4.4 Flange bolts or valve bonnet bolts shall not be used for attaching hangers or foundations.

3.505.3.4.5 Supports shall not be installed on takedown joints or in any way interfere with the installation of takedown joint spray shields.

3.505.3.4.6 Supporting elements, in accordance with Drawing No. 803-5001054, may be used on piping systems 2½ inches (63 mm) nps and smaller where the pipe temperature does not exceed 425 degrees F (218 degrees C), or where spring hangers are not required; however, their restraining effect shall be considered in evaluating the flexibility of the piping system. These supports and their spacing shall be modified as necessary to meet shock requirements.

3.505.3.4.7 Supporting elements for 90 degree angle configuration flexible connections shall be in accordance with Drawing No. 803-5001054.

3.505.3.4.8 Resilient mounts shall be in accordance with Section 3.073. Installation of these supports shall be in accordance with NAVSEA Publication No. 0948-LP-063-9010.

3.505.3.4.9 Where resilient mounts are used for supports, the supports shall be at least two in a "V" configuration with suspension such that each mount shall be loaded along its axis and shall provide maximum pipe support and shock attenuation under vertical and athwartship shock. Where used as sway braces, mounts may be used singularly. The support installation shall be such that the rod of the mount shall be as free from angular deflections as possible, and shall permit vertical adjustment. The maximum angular deflections of the mount from its normal unstressed position shall be as follows:

a) Piping system cold; up to 10 degrees deflection.
b) Piping system at maximum operating conditions; up to 5 degrees deflection.
c) The total angular deflection from the cold condition to the hot operating condition shall not exceed 10 degrees.

3.505.3.4.10 For services up to 650 degrees F (343 degrees C), pipe hangers shall be lined with material to prevent metal-to-metal contact between the pipe clamp and pipe. Applicable liner materials shall be in accordance with Table 505-2. Metallic particles or reinforcing wires shall not be used in any liner materials.

3.505.3.4.11 For hot services, the hanger rod between the pipe clamp and resilient mount shall be of sufficient length to preclude resilient mounts from being subjected to temperatures in excess of 125 degrees F (52 degrees C).

3.505.3.5 Component Identification. Components in piping systems shall be assigned designations in accordance with the requirements herein. These designations shall be used on piping system diagrammatics and arrangement drawings; on diagrams, drawings and sketches in the Ships Information Book (SIB), Damage Control Book, and other manuals; and on piping system label plates.

3.505.3.5.1 Piping system shall be assigned a four-part designation as follows:

a) Shaft or plant number, if associated with a propulsion plant system, such as lubricating oil and ship fuel. (Left blank if not associated.)
b) System designation
c) Component identification
d) Individual component number

Example: 1-PFS-V-1

First Valve in System

Valve

Propulsion Fuel Service

Shaft or Plant Number

In addition, valves in piping systems for progressive flooding prevention and/or material condition of readiness shall have dual designation, and shall also be designated with a basic location number.

Example: 1-MD-V-10
(1-MD-V-3-35-2)

3.505.3.5.2 For remote operated valves, label plates shall also be marked with the basic location number of the remote and local operating station.

3.505.3.5.3 Valves and special fittings provided for damage control functions in piping systems and provided with a remote operator shall also identify the basic location number of their remote operating station.

3.505.3.5.4 System and component designation letters shall be in accordance with Table 505-3.

3.505.3.5.5 Individual component numbers for the four-part designation above shall be assigned in sequence from the origin of a system to its terminus, exclusive of branch lines. Starting at the origin or root connection of a system, the first component in the flow path shall be No. 1, the second similar component in the flow path No. 2, and so on. Where parallel flow paths exist in a system, components in any one of the parallel flow paths shall be numbered in sequence assigning odd numbers to starboard systems and even numbers to port systems. A suffix letter designation for each flow path shall then be employed with the basic component number, to differentiate between flow paths. These suffix letters shall start with "A" and shall be in alphabetical sequence. Letter assignment shall be from starboard to port, then forward to aft, and from a lower to a higher level. New components shall be assigned the number immediately following the last component number assigned in that system.

3.505.3.5.6 Components in each system shall be numbered without respect to components in other systems; that is, there may be several components carrying the same number, but they shall be differentiated by the system designation.

3.505.3.5.7 Pipe and fittings other than those requiring the three-part or four-part designator shall be identified on the piping system arrangement drawings, installation drawings, and fabrication drawings as follows:

Example: P1-8
- Nominal Size in Inches
- Sequential Number (by size or assembly)
- Component Identification: P – Pipe, F – Fitting

3.505.4 Structural Requirements.

3.505.4.1 General. All systems shall have sufficient flexibility to prevent overstressing of piping materials or supports, leakage of joints and unacceptable distortion of connected equipment.

3.505.4.1.1 System flexibility shall consider pressure, weight, thermal expansion, shock, supports and vibration (including that caused by attached machinery). Movements and rotations of terminal points caused by thermal/mechanical deflections and rotations of ship's structure at piping attachment points shall also be considered.

3.505.4.1.2 Design for Pressure Transients. Pressure transients that occur upon change in flow velocity shall not result in objectionable noise levels, detrimental vibration, shock, or excessive internal pressure per Section 3.073. During these pressure transients, the calculated stress in the pipe shall not exceed the maximum allowable stress for the coincident temperature by more than 15 percent during 10 percent of any 24-hour operating period, or more than 20 percent during one percent of any 24-hour operating period. Maximum allowable stress values are given in the Builder Specifications, Tables 505-Va and 505-Vb.

3.505.4.2 Flexibility. Flexibility shall be incorporated into system design by changes of direction in the piping through the use of bends, loops and offsets.

3.505.4.2.1 The following are examples of situations that generally create unacceptable stress levels and therefore, should be avoided:

a) Use of small piping runs in series with larger or stiffer pipe.
b) Localized reduction in size of cross-section of piping.
c) Local use of weaker materials.
d) Line configurations, wherein most of the piping run lies near or on the straight line between end terminals or anchors.
e) Excessive use of supports, particularly rigid rod hangers and similar type restraints, especially on pipe systems subject to thermal movement.

3.505.4.2.2 An informal piping flexibility examination shall be performed for compressed air and flammable fluid systems. This examination shall consist of a visual review of the arrangements of the above systems with regard to piping configuration, support locations, type and structural characteristics, pipe size and wall thickness, material, shape, relative motion between terminals and anchor points, and temperature fluctuations. When this examination results in doubt that adequate flexibility has been provided, detailed calculations shall be performed.

3.505.4.2.3 Detailed piping flexibility calculations shall be prepared and submitted for all systems or portions thereof that are 2 inches (51 mm) or larger, and have a system design temperature higher than 450 degrees F (232 degrees C) or design pressure higher than 150 psi (1,034 kPa).

3.505.4.2.4 Report calculations indicating the results for each system including the parameters considered and rationale applied in accordance with the requirements specified herein.

3.505.4.2.5 Flexibility Calculations. Detailed calculations shall be made in accordance with a recognized method of flexibility analysis. Analysis methods and software shall utilize NSTM S9086-RK-STM-010/Ch. 505 equations and allowable stresses for material. Analysis programs shall contain built-in checks to minimize the possibility of human or machine errors.

3.505.4.2.5.1 The following information shall be prepared:

a) Input data, where calculations are performed by computers.
b) A copy of the working drafts, (no special format) when calculations made by other means, sufficiently complete so the method and assumptions can be evaluated independently.

c) Where detailed flexibility calculations are not required, the system may be analyzed by simplified or approximate methods that are appropriate for the system in question. Approximate or simplified method may be applied only if they are used for the range of configurations for which their accuracy has been demonstrated or documented.

3.505.4.2.5.2 Flexibility calculations between anchor points shall treat the system as whole. Significance of all parts of the system and of all supports and their effect shall be considered. Calculations shall include applicable intensification and flexibility factors for components other than straight pipe. These factors shall be in accordance with ANSI B31.1. If other configurations are used, a complete rationale and justification for these factors shall be provided. Where simplifying assumptions are used, the possibility of underestimating the forces, moments, and stresses shall be considered and forwarded as part of the calculations. Dimensional properties of pipe and fittings shall be based on their nominal dimensions.

3.505.4.2.5.3 The total expansion range for 70 degrees F (21 degrees C) to the maximum system temperature, or from 70 degrees F (21 degrees C) to the lowest system temperature shall be used in calculations. In addition to the movement due to expansion of piping, deflections due to thermal movements of attached machinery and equipment shall be considered.

3.505.4.2.5.4 Flexibility calculations for the stress range, Se, shall be based on the modulus of elasticity, Ec, at 70 degrees F (21 degrees C). For 70-30 copper nickel, MIL-T-16420 or MIL-C-15726, the elastic modulus shall be taken as 22×10^6 psi (152×10^6 kPa).

3.505.4.2.5.5 For all other materials, Ec and other parameters shall be obtained from an authoritative source such as publications of the ANSI Piping Codes or the National Bureau of Standards. The computed stress range shall be combined in accordance with the following formula:

$$Se = \sqrt{(Sb^2 + 4St^2)}$$

Where:

Se	=	computed stress, range in psi.
Sb = iMb/Z	=	effective bending stress in psi.
St = mt/2Z	=	effective torsional stress in psi.
Mb	=	effective bending moment, in-lbs.
Mt	=	torsional moment, in-lbs.
Z	=	section modulus of pipe, in3.
i	=	stress intensification factor.

3.505.4.2.5.6 The maximum computed stress range, Se, based on Ec for the cold condition, shall not exceed the following allowable stress range, Sa;

$$Sa = f(1.25\ Sc + 0.25\ Sh)$$

Where:

Sa	=	allowable stress range in psi.
Sh	=	allowable stress in the hot condition (See Builder Specifications, Tables 505-Va and 505-Vb for stress values).

Sc	=	allowable stress in the cold condition.
f	=	stress reduction factor, applicable to mechanical or thermal cyclic conditions in accordance with the following table. The value for each system analyzed shall be specified.

Number of equivalent full cycles	f
7,000 and less	1.0
14,000	0.9
22,000	0.8
45,000	0.7
100,000	0.6
250,000 and over	0.5

3.505.4.2.5.7 An approved method shall be used to evaluate the effect of combined mechanical and temperature cycles by incorporating the use of a stress reduction factor (f).

3.505.4.2.5.8 The design and spacing of supports shall be analyzed to ensure that the sum of the longitudinal stress due to weight, pressure, and other sustained loadings does not exceed the stress value (Sh) given in the Builder Specifications, Tables 505-Va and 505-Vb.

3.505.4.2.5.9 Calculations and drawings for determining support loading, support type, sustained piping stresses resulting from support arrangement, structural characteristics, and location of all supports shall be prepared with the flexibility calculations for the system under analysis.

3.505.4.2.5.10 The force and moment reactions Rh and Rc in hot and cold conditions based on the modulus of elasticity at room temperature, Ec, as follows.

Reactions in the hot condition:

Rh = R(Eh/Ec)

Reactions in cold condition:

Rc = R(1-(Sh/Se)(Ec/Eh)) where

(Sh/Se)(Ec/Eh) is less than one,

Where:

Ec	=	Modulus of elasticity at 70 degrees F
Eh	=	Modules of elasticity at 70 degrees F
R	=	Reactions from flexibility calculations using Ec
Rc & Rh	=	Maximum reactions estimated to occur in the cold and hot conditions, respectively
Se	=	Maximum computed stress range as determined by the formula above.

3.505.4.2.5.11 Force and moment reactions shall not exceed limits that the connected machinery and equipment can safely sustain, as established by the equipment manufacturer. The design of safety valve piping for reaction loads shall be in accordance with Appendix II of

ANSI B31.1, Power Piping. Detailed isometric diagrams of piping under examination shall form a part of the calculation report.

3.505.4.2.5.12 Calculations shall show maximum stress ranges and their individual locations in each section of piping under examination and shall show force and moment reactions at all connecting units, anchor points, and balance points, and shall include sketches indicating orientation of the principal axis with respect to the centerline of the ship for machinery terminal points. In addition to the above, forces and moments shall also be calculated such that their principal axis coincides with that of machinery and equipment, at terminal points.

3.505.4.2.5.13 Where expansion joints are used, calculations shall be prepared and submitted with the applicable piping flexibility analysis and shall include the following, as a minimum:

a) The thermal movement imposed on the expansion joint.
b) All anchor locations.
c) Expansion in excess of that which the joint can absorb.
d) Reaction at all equipment and anchor points.
e) Cold pull of expansion joints.

3.505.5 Arrangement

3.505.5.1 General. Piping shall permit free passage in walking areas and the performance of normal and emergency operations in designated working areas.

3.505.5.1.1 Piping shall not interfere with the operation or control of machinery and equipment and shall be installed to permit ready accessibility to machinery and equipment for inspection and maintenance. Piping shall not obstruct visibility and access required to control, monitor or adjust machinery, equipment, or their component parts.

3.505.5.1.2 Piping shall be arranged so that machinery and equipment that requires periodic overhaul can be dismantled with a minimum amount of disturbance to the piping. Cutout valves and takedown joints shall be located to isolate sections of piping intended for removal during maintenance, overhaul, or the shipping and unshipping of machinery and equipment so that the least interference with continued operation of the system results.

3.505.5.1.3 Piping shall not obstruct or interfere with the operation of doors, hatches, manholes, scuttles, or openings covered by portable plates, nor obstruct or interfere with the ready and convenient access to access panels, access doors, inspection manholes, handholes, sight glasses, drain plugs, or test cocks used for inspection and maintenance on machinery and equipment.

3.505.5.1.4 Piping shall be arranged so that it shall not normally be subjected to mechanical injury and to preclude its use for other purposes (such as grabrods, handrails and steps). Where this is impracticable, means shall be installed for protecting the piping.

3.505.5.1.5 Piping arrangements that cause turbulent flow detrimental to the system shall be avoided. Inlet piping for centrifugal pumps shall be arranged to avoid air pockets and uneven velocity distribution at the impeller inlet. If the use of an elbow at the pump suction is required by space considerations, long radius type shall be used. Pump suction piping shall be sloped from the source to the inlet of the pump. Whenever high points are located in suction piping at pumps that require priming, the high point shall be primed.

3.505.5.1.6 Unnecessary high and low points shall be avoided in the arrangement of piping. Where necessary for the proper functioning of the system and its connected machinery and equipment, vents and drains shall be installed at the high and low points, respectively.

3.505.5.1.7 Vent valves in flammable liquid or hazardous fluid systems shall be provided with short lengths of tubing to permit collection of escaped liquid in a portable container during venting. Vent tubing shall also be provided for other fluid system vents where necessary to prevent spray or splash or to avoid contact with hazardous fluids.

3.505.5.1.8 Branch connections shall be located to minimize turbulence and the type of connection used (straight or sweep tees and lateral fittings) shall be suitable for the flow characteristics of the system. Erosion shall be minimized by avoiding the use of tees or other fittings that cause a sudden change in direction.

3.505.5.1.9 Insulated piping shall not be located where it is subject to wetting from leakage, condensation, or splashing. In unavoidable situations, the lagging shall be shielded in a manner that shall prevent wetting of the insulation.

3.505.5.1.10 Piping shall not be located where drops or spray from leaks, condensation or splashing would damage electrical or electronic equipment. Where unavoidable, the equipment shall be shielded or metal casings shall be installed around the piping. Casings shall be completely circumferential with a diameter of at least ½ inch (13 mm) greater than the outside diameter of the pipe, including its insulation. Casings shall be open at both ends, with the ends clear of the equipment, and shall be as light as practicable.

3.505.5.1.11 Splash or deflector plates shall be provided at the terminal of frequently used drains to the bilge to prevent direct water impingement on foundations and ship structure such as shell plating and tank tops.

3.505.5.2 Structural. The piercing of decks and bulkheads shall be minimized, particularly the piercing of transverse main subdivision bulkheads.

3.505.5.2.1 Where piping passes through a boundary having a degree of tightness other than nontight, components and installation procedures shall be selected to maintain the required degree of tightness.

3.505.5.2.2 Where piping passes through holes in nontight structure, provision shall be made to keep the pipe from bearing on the structure.

3.505.5.2.3 Piping shall be kept clear of removable plates (BERPs) provided in the ship structure for the shipping and unshipping of machinery or equipment. Where it is impracticable to keep class P-1 piping, 4 inches (102 mm) nps or larger, clear of designated areas marked for removal of plates in the ship structure for installation and removal of machinery or equipment, it shall be flanged to facilitate its removal.

3.505.5.2.4 Deflections of bulkheads, decks and other structure due to shock loading, fluid (gas or liquid) pressure, or the working of the ship shall be considered in the arrangement of piping, and the necessary clearance and flexibility shall be provided.

3.505.5.2.5 Piping shall be arranged to permit maintenance of ship structure.

3.505.5.3 Valves and Components. In the arrangement of piping, valves shall be located and oriented to permit convenient operation of the valve. Remote operating gear or valve extension stem shall be provided for valves that are not accessible. A remote valve position indicator shall also be provided in view of personnel operating the handwheel.

3.505.5.3.1 Valves in horizontal piping shall be arranged with their valve stem pointing above the horizontal wherever practicable.

3.505.5.3.2 Thermometers, gauges, gauge glasses and other monitoring equipment or devices shall be arranged to permit ready vision or audibility from equipment operating areas. If the operating area is not defined, the instruments shall be visible from the normal walkways or access.

3.505.5.3.3 High maintenance items that cannot normally be repaired in place shall be fitted with takedown end connections.

3.505.5.3.4 Valves and components welded or brazed into the piping shall be accessible for repair, reseating and overhaul in place. They shall be located to permit removal, rewelding, rebrazing, preheating and stress relieving, as necessary, in the event of major repair or replacement. Sufficient clearance shall be provided around welded valves to permit in place use of the valve reseating machines. Damage control valves used for isolation and segregation shall be installed in an accessible location.

3.505.5.3.5 Globe and angle valves shall be arranged with the system pressure or vacuum under the disc so that in the shut position the pressure or vacuum is not exerted on the bonnet joint or stem packing.

3.505.5.3.6 Check valves shall be selected and oriented so that their characteristics are compatible with the system requirements and ship motion requirements.

3.505.5.4 Fire Hazard Reduction. Any surface having a temperature in excess of 400 degrees F (204 degrees C) under the insulation is defined as a hot surface. Where lube oil is the flammable fluid under consideration, a surface having a temperature in excess of 650 degrees F (343 degrees C) is defined as a hot surface.

3.505.5.4.1 Combustible or flammable fluid piping shall be kept as far from electric equipment as practicable.

3.505.5.4.2 Hot surface piping and equipment shall be installed at least 18 inches (46 cm) away from tanks containing flammable fluids.

3.505.5.4.3 Piping containing flammable fluids shall be installed at least 18 inches (46 cm) from any hot surface.

3.505.5.4.4 Spray Shields. Spray shields to prevent spray from impinging on a hot surface or electrical equipment, or formation of an atomized mist in the event of a gasket or strainer leak, shall be aluminized glass cloth construction in accordance with Drawing No. 803-2145518.

3.505.5.4.4.1 Spray shields shall be installed on flanged joints and flanged valve bonnets in piping containing lubricating oil and flammable fluids located in the direct plane of, and 10 feet (3 meters) or less from an electrical switchboard, electrical equipment enclosure, motor or hot surface. Protection is not required for electrical equipment that is watertight, spraytight, totally enclosed, submersible or explosionproof.

3.505.5.4.4.2 Spray shields are not required for the following:

a) Piping that can not be pressurized.
b) Gaugeline piping downstream of a root valve, except for flanged connections.
c) Piping below floor plates.
d) Union and union type fittings.

3.505.5.4.5 Fuel and lube oil duplex strainers subject to pump discharge pressure shall be provided with safety shields in accordance with the design guidance of NAVSEA Publication No. 0948-LP-102-2010.

3.505.5.4.5.1 The following label plate shall be placed on the safety enclosure.

CAUTION
FUEL AND LUBE OIL STRAINERS SHALL NOT BE
OPENED WHEN SYSTEMS ARE PRESSURIZED.

3.505.6 Fabrication and Installation

3.505.6.1 Fabrication. Welding of piping system joints shall be in accordance with NAVSEA Publication No. S9074-AR-GIB-010/278.

3.505.6.1.1 Brazing of piping system joints shall be in accordance with NAVSEA Publication No. 0900-LP-001-7000.

3.505.6.1.2 Silver-brazed joints are prohibited in the fuel, lube oil and compressed air system.

3.505.6.1.3 Flanged joints shall be assembled in accordance with NSTM S9086-RK-STM-010/Ch. 505.

3.505.6.1.4 The bending, fabrication and control of piping and tubing shall be in accordance with MIL-STD-1627. Thinning at any point as a result of bending shall not exceed 20 percent of the wall thickness of the pipe or tube.

3.505.6.1.5 Branch connections in piping shall be made by the use of integral fittings such as tees, laterals, bosses and crosses. Fabricated branch outlets shall not be used. Unreinforced branch connections shall not be permitted in any system where the design pressure is over 150 psi (1,034 kPa) or temperature over 449 degrees F (232 degrees C). Obtaining the required reinforcement via weld build-up is not permitted and any branch connection fabricated via the use of welding only shall be considered as unreinforced.

3.505.6.2 Installation. Clamps and similar support devices shall not be welded to the system being supported or components thereof.

3.505.7 Quality Assurance and Cleaning.

3.505.7.1 Test-Inspection, Components. For piping system tests see Section 3.095. The following requirements apply to components that are not covered by Government specifications, standard drawings, or approved industry standards:

a) Proof Pressure Test – The design pressure of piping components whose strength cannot be computed with satisfactory assurance of accuracy, shall be determined by conducting a proof pressure test on the first unit (every size) of a new design. This test shall be conducted in accordance with the procedures specified in the ASME Boiler and Pressure Vessel Code, Section VIII, and the design pressure (the Section VIII maximum allowable operating pressure) shall be established by one of the methods listed therein, as approved by NAVSEA.

b) Hydrostatic Pressure Test – A hydrostatic pressure test of at least 135 percent of the cold service rating of the component shall be applied to the component to check joint tightness and soundness of the pressure containing boundary. There shall be no permanent distortion, or other distortion that could adversely affect operation of the component. This test shall generally be run with clean fresh water. Where water would have a detrimental effect on the component or would necessitate the disassembly, cleaning, or relubrication of the component, other fluids, as approved, may be used as the test media.

c) Valve Seat Leakage Tests – Valves shall be given a 3 minute minimum seat leakage test at their design pressure or as specified below:

1. Stop Valves
   - (a) Metal-to-Metal Seated – A maximum leakage rate of 10 cc/hr/in of nominal pipe size. For valves less than 1 inch (25 mm) nps in size, a maximum leakage of 10 cc/hr is permissible.
   - (b) Soft Seated Valves – No visible signs of leakage.
   - (c) The test fluid shall be clean fresh water.
   - (d) The handwheel force for seating manually-operated valves shall not exceed the handwheel seating forces listed in Table 505-1. Where a valve is power-actuated, the seating force generated by the actuator may be used to seat the valve.
   - (e) For testing globe valves, the pressure shall be applied in the direction tending to open the valve. For testing gate, ball, and butterfly valves, tightness shall be alternately checked with pressure applied in each direction.
2. Relief Valves – Seat tightness tests on relief valves shall be conducted at the required reseat pressure as determined by MS-18282.
3. Check Valve – Seat tightness tests conducted on check valves shall be performed with clean fresh water at a backpressure of 50 psi (345 kPa) for valves with a primary pressure rating of 150 psi (1,034 kPa) and below and at 100 psi (689 kPa) for valves with primary pressure ratings over 150 psi (1,034 kPa). For metal-to-metal seated valves, the leakage rate shall not exceed 25 cc/hr/in of nominal pipe size up to 2 inches (51 mm) inclusive, 50 cc/hr/in of nps from 2½ to 10 inches (63 to 254 mm) inclusive, and 100 cc/hr/in of nps over 10 inches (254 mm). For valves 1 inch (25 mm) and smaller, the leakage rate shall not exceed 25 cc/hr. No leakage shall be permitted for valves incorporating a soft seating feature.

3.505.7.1.1 Shock Tests. Mechanical components shall satisfy the requirements of Section 3.072. Pipe flanges, and standard fittings are not required to be high impact shock tested. The positions and pressure conditions under which valves shall be mechanically shock tested shall be in accordance with MIL-STD-798.

3.505.7.1.2 Vibration. Components shall be of a design to meet the vibration test in accordance with MIL-STD-167-1 to determine the suitability of the design for vibration.

3.505.7.2 System Cleaning Requirements. Applicable levels of cleanliness shall be achieved and maintained as described below. Flushing for cleanliness and for flux removal shall be accomplished prior to hydrostatic testing.

3.505.7.2.1 Cleanliness Levels. Cleanliness levels are as follows.

a) Level II – Cleanliness Level II is a degree of cleanliness that results in a surface visually free of grease, oil, flux, scale, dirt, loose particles and any other contamination foreign to the base metal. Tap water residues on all metals and light superficial rust on carbon steel surfaces, caused by short time exposure to the atmosphere, are permitted. Light dust on clean surfaces is not objectionable, provided that the quantity and size of the particle does not adversely affect system operations.
   1. Lubricating Oil System
   2. Diesel Freshwater Cooling
   3. Fuel Service System
   4. Medium Pressure Air (above 250 psi (1720 kPa) and below 1500 psi (10,340 kPa))

b) Level III – Cleanliness Level III is a degree of cleanliness that results in a surface that is reasonably free of contamination and any remaining residue on the surface does not interfere with system operations or damage system components.
   1. HALON
   2. Diesel Seawater Cooling
   3. Main Seawater Cooling
   4. Auxiliary Seawater Cooling
   5. Diesel Exhaust System
   6. Oily Waste System
   7. Combustion Air System

3.505.7.2.2 Flux Removal. P-3 brazed (see NAVSEA Publication No. 0900-LP-001-7000) piping systems shall be flushed as specified herein for flux removal. This flush may be combined with cleanliness flushing provided the procedure includes a water flush or soak of equal time and temperature. One of the three following procedures shall be conducted (the hot flush and hot circulation methods are preferred):

a) Hot flush with freshwater for 1 hour while ensuring that the temperature at any part of the system does not go below 110 degrees F (43 degrees C).
b) As an alternative to the hot flush procedure, a hot recirculating procedure with freshwater may be conducted for a period of 1 hour for systems where such an arrangement is feasible. Again, the system temperature shall be monitored so that no part of the system falls below 110 degrees F (43 degrees C). Following the recirculating, the system shall be flushed with clean fresh water for 15 minutes at a minimum temperature of 60 degrees F (15 degrees C).
c) Cold soak the system for 12 hours using clean fresh water at a minimum of 60 degrees F (15 degrees C). At the completion of the 12 hour soak, systems shall be flushed with clean fresh water at a minimum of 60 degrees F (15 degrees C) for 4 hours.

3.505.7.2.2.1 Under the above flux removal procedures, the system shall be full of water so that joints are completely submerged at all times. The minimum velocity for removal of residual brazing flux in piping systems shall be 1 ft/sec (.3 m/sec).

TABLE 505-1
Maximum Allowable Tangential Force to Seat
Valves Based on Valve Handwheel Size

Handwheel Diameter inches	(mm)	Lever Length inches	(mm)	Seating Force pounds	(kg)
2	(51)	--	(--)	90	(41)
3	(76)	--	(--)	98	(44)
4	(102)	--	(--)	106	(48)
5	(127)	--	(--)	112	(51)
6	(152)	4	(102)	118	(53)
7	(178)	--	(--)	122	(55)
8	(203)	5	(127)	124	(56)
9	(229)	--	(--)	128	(58)
10	(254)	6	(152)	130	(59)
11	(279)	--	(--)	132	(60)
12	(305)	7	(178)	136	(62)
14	(356)	8	(203)	138	(63)
16	(406)	9	(229)	140	(64)
18	(457)	10	(254)	142	(64)
21	(533)	11	(279)	144	(65)
24	(610)	13	(330)	150	(68)
27	(686)	14	(356)	150	(68)
30	(762)	16	(406)	150	(68)
36	(914)	19	(483)	150	(68)

TABLE 505-2
Pipe Hanger Liner Material

Service Application and Temperature	Liner Material and Form	Applicable Specification
In Contact (Note 1) with Fuel and Lube Oil Up to 180°F (82°C)	Synthetic Rubber Channel, Block	MIL-R-6855, Class 1, Grade 60
In Contact (Note 1) with Fuel and Lube Oil Up to 500°F (260°C)	Fluorocarbon Rubber Channel, Block	SAE AMS-3216
Other than above Up to 180°F (82°C)	Synthetic Rubber Channel, Block	MIL-R-6855, Class 2, Grade 60
Other than above Up to 425°F (218°C)	Silicone Rubber Channel, Block	A-A-55754, Class 2, Grade 60
Other than above Over 180°F (82°C) up to 650°F (343°C)	Fibrous Glass Tape	MIL-C-20079, Type II, Class 4
Other than above 650°F (343°C) and over	None (Note 2)	As specified by NAVSEA

NOTES:

(1) In contact means applications where the liner may be permanently or intermittently immersed in the liquid such as "in-tank" applications.
(2) Minimum contact area type hangers as shown on NAVSHIPS Drawing No. 804-1385781 are used without liners.

TABLE 505-3
System and Component Designations

System	Designation
Seawater cooling (Notes 1, 2 and 3)	ASW
Fuel service - propulsion	PFS
Fuel service - generator	GFS
HALON 1301 fire extinguishing system	HALON
Jacket water	JW
Lube oil fill and transfer - IFVG	ILO
Lube oil fill and transfer - Dirty Lube Oil	DLO
Lube oil fill and transfer - propulsion	PLO
Lube oil fill and transfer - generator	GLO
Lube oil service - propulsion	PLOS
Lube oil service - generator	GLOS
Machinery waste water drain collecting	WW
Oily water drain collecting	OW
Starting air - propulsion	PSA
Starting air - generator	GSA

Component identification letters shall be in accordance with the following:

V - Valve
F - Special Fitting, such as strainer, filter, mating connection, quick disconnects
GA - Gauge
TH - Thermometer
FS - Float switch
DP - Differential pressure detector
PT - Pressure transmitter
PS - Pressure switch
LS - Liquid level switch
OR - Orifice
PD - Propulsion damper

NOTES:

(1) Includes seawater cooling for propulsion, diesel generators, auxiliary machinery, auxiliaries, and miscellaneous systems and equipment.

(2) That portion of the central seawater cooling system common to all seawater demands shall be designated SW. Those portions of the central seawater cooling system associated with propulsion shall be designated MSW; and those associated with auxiliary machinery, auxiliaries, and miscellaneous systems and equipment shall be designated ASW.

(3) Seawater cooling systems for diesel generators shall be designated GSW; for air conditioning and refrigeration condensers, ACSW; and for firemain supplied systems, ASW.

3.508 Thermal Insulation for Machinery, Equipment and Piping

3.508.1 Definitions.

a) Anti-Sweat Insulation – A type of thermal insulation applied on components to either prevent formation of condensation on their external surfaces or to limit absorption of external heat that would be detrimental to the system operation.
b) Fastenings – Items such as hooks, wire and adhesive used to secure insulation materials and lagging.
c) Hot Surface Insulation – A type of thermal insulation applied on external surfaces of components that are 125 degrees F (52 degrees C) or higher to protect personnel and limit undesirable heat transfer.
d) Lagging – A protective and confining covering or jacket such as cloth, tape or sheet metal, applied over insulating materials.
e) Machinery Covering or Pipe Covering – A composite covering including a thermal insulation, its fastenings, lagging and vapor barrier, when specified.
f) Reusable Covers – Machinery covering or pipe covering that can be removed without being damaged and can be easily replaced for continued use.

3.508.2 General Requirements. Following are performance requirements for thermal insulation for machinery, equipment and piping associated with engine replacements. Thermal insulation shall deliver thermal protection to surrounding equipment and personnel. System shall meet requirements of Section 3.505 and as follows.

3.508.3 Application.

3.508.3.1 Hot Surface Insulation. All components having hot external surfaces shall be insulated in accordance with the following criteria:

a) Surfaces that can attain a temperature of 125 degrees F (52 degrees C) or higher during any service condition shall be insulated wherever necessary to protect personnel, prevent undesirable transfer of heat to the surroundings, or prevent transfer of heat from the component wherever such transfer would be detrimental to operation of the component or system.
b) Insulation shall not be installed for:
    1. Any hot surface for which freedom from insulation is essential for its proper operation.
    2. Relief valves, beyond discharge, except as required for personnel protection.
    3. Pressure gauge piping
    4. Piping in bilges
c) Shielding shall be installed where there is a possibility of oil impingement on surfaces that are excluded from insulation requirements, and that can attain a temperature of 400 degrees F (204 degrees C) or higher. Where the only flammable fluid that can impinge on a hot surface is lube oil, the temperature criteria for shielding of the hot surface shall be a surface temperature of 650 degrees F (343 degrees C) or higher. Additional safety requirements shall be as specified in Section 3.505.

3.508.3.2 Anti-Sweat Insulation. Seawater piping shall be insulated in accordance with the following criteria:

a) To limit absorption of heat from an external source that would be detrimental to the system.

b) To prevent formation of condensation on surfaces of components that would be objectionable from:
   1. A habitability standpoint, such as condensation dripping on personnel.
   2. A danger standpoint, such as condensation dripping on electrical and electronic equipment
   3. A damage standpoint, such as condensation dripping on stores or supplies.
   4. A maintenance standpoint, such as condensation dripping on machinery, equipment, or painted surfaces of bulkheads or decks that are normally kept in ship-shape condition.

c) Insulation shall cover pipe hanger clamps.
d) A vapor barrier shall be installed so that it completely seals all joints, including spaces around pipe hanger rods, and shall remain intact under service operating conditions.
e) Insulation shall not be installed for piping in the bilge.

3.508.3.3 Lagging. Lagging shall be applied as specified in MIL-STD-769. Non-magnetic metal lagging shall be installed, where necessary, for protecting insulation from damage such as in areas of heavy traffic, and where insulation can become oil or water soaked. A surface treatment or covering shall be installed on metal lagging where necessary for protection of personnel.

3.508.4 Materials and Thickness. Under no circumstances shall asbestos be used. Materials and minimum acceptable thickness shall comply with MIL-STD-769. Where a choice of two or more kinds of insulation is specified for one temperature range, any one specified may be installed, provided it is installed on an entire system and compatible components are used throughout, with the exception that rigid and non-rigid insulation may be used on the same system to facilitate the installation of pipe hangers. One of the lighter weight (lower density) materials specified shall be chosen.

3.508.4.1 Materials, such as adhesives, that are in contact with piping, shall not have any adverse effect on the piping material; for example, insulating materials that can give off halides harmful to corrosion-resisting steel shall not be used.

3.508.5 Installation. Machinery and pipe covering shall be installed in accordance with requirements herein and those specified in MIL-STD-769. Surfaces to which insulation shall be applied shall be cleaned and prepared as specified in Section 3.631.

3.508.5.1 Specified pressure tests of piping shall be completed before pipe covering is installed over mechanical joints. Covering shall be in place for sea trials.

3.508.5.2 Machinery and pipe covering shall be installed so that movements of the components, due to thermal or other forces, shall not damage the covering in any way. Fastenings shall not crush or otherwise reduce the insulating value of insulation.

3.508.5.3 Fastenings provided on components by manufacturers shall be adequate for installation of the specified insulation.

3.508.5.4 Where reusable covers are used at takedown joints, the covering shall be installed in such a manner so as not to interfere with servicing of the joint.

3.508.5.5 All lagging shall be fitted securely, neatly and smoothly; sheet metal lagging shall have smooth edges.

3.508.6 Reusable Covers. Fabrication and installation of reusable covers shall comply with MIL-STD-769.

3.508.6.1 For hot surface applications requiring insulation, reusable covers shall be installed to permit servicing of machinery, equipment, pipe, and valve takedown joints.

3.508.6.2 Reusable covers shall not be installed where a vapor barrier is used in conjunction with anti-sweat thermal insulation.

3.508.6.3 For units of machinery, equipment, or for some piping components, where it would be impractical to install both permanent insulation and reusable covers, the entire insulation may be made reusable.

3.509 <u>Thermal Insulation and Acoustic Absorptive Treatment for Ducts and Trunks</u>

3.509.1 Definitions.

a) Sheathing – A protective covering of sheet metal applied over thermal insulation.
b) Thermal Insulation – An insulation applied to ducts and equipment to limit heat losses or gains, to prevent condensation and to protect personnel.
c) Vapor Barrier – A coating compound applied to the exterior surface of the lagging to prevent the penetration of vapor.

3.509.2 General. Surfaces shall be cleaned and prepared as specified in Section 3.631 before they are insulated.

3.509.2.1 Fastenings shall not crush or otherwise reduce the insulating value of the insulation.

3.509.2.2 Sheathing shall be installed, where necessary, to protect insulation from damage. Where such ducts extend vertically through the deck, the sheathing shall be provided from the deck to at least 2 feet (61 cm) above the working surface of the fixture.

3.509.3 Thermal Insulation. Thermal insulation shall be applied on parts of trunks or ducts including their flanges, of ventilation supply systems carrying unheated air that pass through normally heated spaces, and on parts of trunks or ducts of supply systems that pass through or terminate in heat producing spaces.

3.509.4 Removable and Replaceable Thermal Insulated Covers. Removable and replaceable insulated covers shall be installed on access covers for insulated portions of ventilation systems where the access cover itself does not incorporate thermal insulation. Where necessary, covers shall be quilted to maintain uniform thickness, strength and rigidity. Covers shall be secured in place by lacing or similar means.

3.509.5 Materials. The following materials shall be used for thermal insulation.

a) Thermal Insulation for Ducts – For round ducts, 1 inch (25 mm) fibrous glass blanket, MIL-I-22023, type I (lagged); or 1 inch (25 mm) fibrous glass covering MIL-I-22344, (lagged). For rectangular and flat oval ducts, 1 inch (25.4 mm) fibrous glass blanket, MIL-I-22023, type I (lagged) or 1 inch (25 mm) fibrous glass cloth faced board, MIL-I-742, type I (not lagged) or 1 inch (25 mm) fibrous glass unfaced board, MIL-I-742, type II (lagged); except that type I shall be used on ducts with a flat bottom surface 9 inches (23 cm) or more in width.

b) Thermal Insulation for Trunks and Duct Heaters – One inch (25 mm) fibrous glass board, MIL-I-742, type I.
c) Insulated Covers – Fibrous glass blanket, MIL-I-22023, type I, class 5, 1 inch (25 mm) thick, placed between sheets of fibrous glass cloth, MIL-C-20079, type I, class as applicable.
d) Sheathing for Thermal Insulation – Corrosion resisting steel no. 22 USSGA, ASTM A666, Series 310, nonmagnetic 2B finish shall be used.
e) Vapor Barrier – On faced board and on fibrous glass cloth, three alternate coats white, orange, and white, in that order, of coating compound, MIL-C-19565.
f) Thermal Insulation for Flanges – Fibrous glass blanket, MIL-I-22023, type I.
g) Lagging – Fibrous glass cloth, tape and thread, MIL-C-20079.
h) Adhesive – Adhesive, MIL-A-3316.

3.509.6 Installation. Thermal insulation lagging for trunks or ducts shall be installed in accordance with drawings, NAVSHIPS Nos. 804-5773931 and 804-5773932, except nonmagnetic material shall replace magnetic material.

3.509.6.1 The installation procedure shall be prepared using Drawing No. 804-5773932 as guidance. The installation procedure shall be approved by NAVSEA.

3.509.6.2 Where preformed insulation is used on round ducts, the longitudinal seams preceding and following the butted joints shall be staggered. Longitudinal seams shall be supported at approximately 18 inch (46 cm) intervals by a 2 inch (5 cm) wide fibrous glass cloth tape.

3.509.6.3 Where banded duct connectors are used in lieu of flanges, the duct insulation and lagging shall terminate 1 inch (25 mm) from each side of the connector. A strip of fibrous glass blanket covered with fibrous glass cloth shall then be fitted around the connector, between the terminations of the duct insulation, and held in place by two low magnetic permeability sheet metal straps 1 inch (25 mm) wide. A vapor barrier, if required, and paint shall then be applied.

3.512 <u>Heating, Ventilation and Air Conditioning (HVAC)</u>

3.512.1 Definitions.

a) Air Conditioning – The control of dry bulb temperature and limitation of relative humidity by means of mechanically cooled, recirculated air.
b) Project Peculiar Document (PPD) – Where PPD is specified in this section, it refers to Project Peculiar Document, "Air Conditioning, Ventilation and Heating Design Criteria Manual for MCM".
c) Replenishment Air – Weather air that is supplied to air-conditioned compartments to maintain an acceptable level of air purity.
d) Ventilation – The movement of air from the weather into the ship or from the ship out to the weather by fans or ductwork, or both.

3.512.2 General Requirements. Duct sections over generators and generator terminals shall be avoided if at all possible. If duct sections must be routed over such equipment, the ducting shall either be of watertight construction or made driptight by welding or soldering. Straight duct sections with seam only at top do not require sealing. Ducts shall be arranged to preclude duct connections over equipment.

3.512.3 Terminals. Terminals and hoods shall be constructed of CRES. Supply terminals shall be adjustable blast type for ventilation systems. Dampers shall be omitted in adjustable blast type supply terminals in machinery spaces.

3.512.3.1 Where adjustable blast terminals are required in spaces containing gear or bearing housings, tamperproof stops shall be provided on the terminals to prevent discharging air across equipment; adjustability in other directions shall be retained.

3.512.4 Damage Control Requirements. Ducts serving a watertight space or a group of spaces protected by a watertight envelope below the bulkhead/damage control deck shall extend individually watertight from the watertight boundary penetration to FWL-1 as defined in Section 3.070 for the main transverse bulkhead forward or aft of the spaces under consideration, whichever is higher, except that ducts of recirculating air conditioning systems serving watertight spaces manned during general quarters may be non-watertight provided they pierce only watertight bulkheads other than main transverse bulkheads, or pierce only one watertight deck.

3.512.4.1 Watertight closures are required as follows:

a) At bulkhead penetrations in ducts that pierce watertight bulkheads below FWL-1 as defined in Section 3.070.
b) At watertight boundary penetrations in ducts serving magazines.
c) At weather openings likely to ship seawater. Where practicable, openings shall be located or designed to eliminate closures.
d) At boundary penetrations in ducts serving S.D. Storeroom (Flammable Materials), if ducts are connected to a system that serves other compartments.

3.512.4.2 Regardless of the above requirements, closures shall not be installed in ducts serving spaces from which internal combustion engines or air compressors take air, and Main Machinery Room and Auxiliary Machinery Room.

3.512.4.3 Where closures are required at duct penetrations of compartments, they shall be located as close to the penetration as is practicable. Upon approval, watertight elbows or extended coamings may be fitted at the boundary to be protected, and the closure installed immediately thereafter if it is impracticable to provide the closure immediately before or after the penetration.

3.512.4.4 Ventilation closures of the butterfly type, round or flat oval, shall be in accordance with Drawing Nos. 804-1749102, Rev. C, or 804-1749103, Rev. C, respectively.

3.512.5 Construction Requirements. All ductwork shall be made of corrosion resisting steel (CRES) with a low magnetic permeability, ASTM A240/A240M, Class 310 or Copper-nickel alloy, MIL-C-15726, 70-30.

3.512.5.1 Seamless or welded tubing may be used for round or flat-oval ductwork. Machine bending of tubing is allowable.

3.512.5.2 Commercially manufactured spirally wound duct and fittings may be used for round or flat-oval non-watertight ductwork.

3.512.5.3 Where ducts are required to connect to dissimilar metals, faying surfaces shall be treated in accordance with Section 3.631.

3.512.5.4 Blind rivets, MIL-R-7885, may be used in non-watertight ductwork.

3.512.5.5 Sheet metal screws shall not be used in duct construction.

3.512.5.6 he interior of ducts subject to corrosive fumes shall be given a protective coating as required by Section 3.631.

3.512.5.7 ucts shall be fitted with accessible petcocks or drain plugs for draining, where necessary.

3.512.5.8 ype "E" terminals shall be CRES, ASTM A240/A240M, Class 310, with a low magnetic permeability.

3.512.5.9 ll fittings, equipment, and ducts in way of magnetic compasses shall be of nonmagnetic material in accordance with Section 070 of the Builder Specification.

3.512.5.10 Where corner radii are required on rectangular ducts, the connecting duct need not be faired in, if the reduction in area is 5 percent or less.

3.512.5.11 The minimum thickness of materials for ducts shall be as given in Table 512-1 and 512-2.

Table 512-1
Min Thickness of Materials for Ducts Non-Watertight

Diameter or Longer Side in Inches	Aluminum or CRES Inches	(mm)	Copper Nickel Alloy Inches	(mm)
Up to 6	.018	(.46)	.018	(.46)
6½ to 12	.030	(.76)	.030	(.76)
12½ to 18	.036	(.91)	.038	(.97)
18½ to 30	.048	(1.22)	.048	(1.22)
Above 30	.060	(1.52)	.060	(1.52)

Table 512-2
Min Thickness of Materials for Ducts Watertight

Diameter or Longer Side in Inches	Aluminum or CRES inches	(mm)	Copper Nickel Alloy inches	(mm)
Up to 6	.075	(1.91)	.075	(1.91)
6½ to 12	.100	(2.54)	.100	(2.54)
12½ to 18	.118	(3.00)	.118	(3.00)
18½ to 30	.118	(3.00)	.118	(3.00)
Above 30	.118	(3.00)	.118	(3.00)

3.512.5.12 The thickness of material for fittings such as elbows, tees and transitions shall be that required for the largest dimensions of the fitting.

3.512.5.13 In areas where a turn is required upstream of axial fans, coils, heaters and supply system takeoffs, the following criteria apply:

a) Radius elbows may be used, provided the minimum length of straight duct between the turn and the fitting is equal to the duct dimension in the plane of the bend times:
   1. Two, for 30 degree elbows.
   2. Three, for 45 degree elbows.
   3. Four, for 60 degree elbows.
   4. Five, for 90 degree elbows.
b) Radius elbows with splitters may be used, provided the minimum length of straight duct between the turn and fitting is equal to the dimension between the longest splitter and the outer curve of the elbow times:
   1. Two, for 30 degree elbows.
   2. Three, for 45 degree elbows.
   3. Four, for 60 degree elbows.
   4. Five, for 90 degree elbows.
c) Vaned turns conforming to Drawing No. S3801-385260 shall be used, if the length of straight duct between the turn and the fitting is less than that required above; otherwise, radius elbows are preferred.

3.512.5.14 Welded construction is preferred for watertight ductwork. If welded joints are not used, ductwork shall have a minimum number of flanged joints. Slip joints shall not be used. Gaskets for flanged joints shall comply with Drawing No. 803-B-153. Where flange protrusion below the headroom level specified in Section 3.071 cannot be avoided and a headroom flange cannot be used, the flange shall be padded to prevent injury to personnel.

3.512.5.15 Non-watertight ducts, other than round, shall have flanged connections. Round ducts shall have flanged joints, an approved flexible coupling, or an approved banded type sleeve connector.

3.512.5.16 Ducts shall be fair and smooth inside. Flanges and gaskets shall not protrude into the air stream. Sharp edges facing air flow and fastenings that extend into the duct are not permitted. Leading edges of dampers, splitters and deflectors shall be rounded or folded back.

3.512.5.17 Splitters, closures and other necessary obstructions within ducts and operating gear for dampers shall be designed to preclude vibration and noise.

3.512.5.18 Flexibility shall be provided in ducts and trunks that extend between portions of structure subject to relative movement.

3.512.5.19 System balance shall be achieved through use of orifice plates.

3.512.5.20 Access openings for cleaning shall be provided in exhaust ducts serving the machinery spaces, so that interior areas of the ducts from the exhaust inlet to the weather can be reached and cleaned by hand (not more than 6 feet (1.8 meters) apart).

3.512.5.21 Access openings shall be located in the bottom of the duct unless the side is more accessible. Accesses shall be located to ensure that they shall be readily accessible without first dismantling other installations.

3.512.5.22 For ducts that are 12 inches (30 cm) or less in width the access shall be a removable 24 inch (61 cm) long flanged section of duct. For ducts that are over 12 inches (30 cm) in width, the access shall be a removable cover plate.

3.512.5.23 The width of the access cover plate shall be equal to the width of the duct less 2 inches (51 mm) for flanges, and the length of the access cover plate shall be 24 inches

(61 cm), if the section of duct shall permit. The cover plate shall be of the same material and thickness as the duct or trunk to which it is attached. A gasket shall be fitted between the access cover plate and duct or trunk. The access cover plate shall be secured by the use of captive-hexagon head machine screws threaded into a tapping strip, or into pressed-in or welded nuts.

3.512.5.24 For inspection purposes, in non-watertight ducts, removable access cover plates on the air inlet side of vaned turns, orifice plates and splitters shall be fitted with a quick-operating round or flat-oval cover. In exhaust systems serving the machinery spaces, removable access cover plates in the ductwork shall have a quick-operating round or flat-oval cover installed in the first access cover plate after the air inlet and in every fourth access cover plate thereafter.

3.512.5.25 Quick-operating round access covers shall conform to Drawing Nos. 805-1363772, 805-1363775 and 805-1363776, and flat-oval access covers shall conform to Drawing No. 501-1131916, except that both the round access covers and the flat access covers shall be fabricated from low magnetic permeability CRES, ASTM A240/A240M, Class 310. Quick-operating access covers shall be secured to the removable access plates by a 1/16 inch (1.6 mm) 7 by 7 wire rope of compatible material at least 8 inches (20 cm) in length.

3.512.6 Controls.

3.512.6.1 Preheaters. Ventilation preheaters shall be controlled by an enforced zero-voltage firing thyristor power controller mounted in an enclosure conforming to Section 3.300, and shall be equipped with the following additional features:

a) Integral I^2T quick blow fuses.
b) Integral phase rotating indicating lights on 3-phase units.
c) Control voltage transformer with fused primary.
d) Three leg control on 3-phase units.
e) Bias and gain adjustments.

3.512.6.1.1 Thermostat for preheater controls shall be an all solid state, non-indicating, proportional controller mounted in thyristor control cabinet.

3.505.6.1.2 Sensing element shall be a duct mounted Iron Constantan type J thermocoupler, or equal. Thermostat shall be set for a constant preheated air delivery temperature as specified in the PPD.

3.512.6.2 Space Heater Control. Space heater type T shall be thermostatically controlled by a dual temperature control switch (2PD).

3.512.6.3 Fan Motor Controllers. Fan motors of systems serving spaces that have HALON 1301 fire protection systems installed shall be controlled as depicted on their Primary Diagram, but modified as depicted on Diagram No. 11 of the PPD. Each fan that serves a space in which a HALON 1301 fire protection system is installed shall have a pressure operated switch to stop the fan motor before the HALON 1301 is released. For location of pressure operated switches and time delay devices, see Section 3.555.

3.512.6.3.1 Fan motors of systems serving the Main Machinery Room, Generator Rooms, and Auxiliary Machinery Room shall be controlled as depicted on Diagram No. 13 of the PPD.

3.512.6.3.2 Controls of auxiliary equipment, such as motor generator sets, shall receive power from the load side of their respective fan controllers as depicted on Diagram No. 17 of the PPD.

3.512.6.3.3 Motor controllers for fans serving the Main Machinery Room, Generator Rooms and Auxiliary Machinery Room shall be located outside the space served and away from heat producing equipment.

3.512.6.3.4 A remote switch with speed control and running indicator status lights shall be provided for each fan or pair of fans, as required, and located as follows:

a) Fan or fans serving a single compartment shall have the remote switch located within the space served, unless otherwise specified herein.
b) Fans serving a compartment where the fan motor is explosionproof shall have the motor controllers and remote switches for all the fans serving that compartment, located outside of the space (including access where open to the space) near the space access.
c) Fans serving the Main Machinery Room, and Auxiliary Machinery Room shall have remote switches located near their respective controllers. A switch S-12 shall be located outside of each space at the access to the space. Switch S-12 shall have 2 pushbuttons. One pushbutton shall emergency stop all fans serving the space and shall be labeled “FIRE-STOP.” The other pushbutton shall start the exhaust fans (high speed only) and shall be labeled “DE-SMOKING.” Switch S-12 shall be provided with a hinged cover and a label plate inscribed "FOR EMERGENCY USE ONLY."

3.512.6.3.5 If more than one fan serves a single compartment, remote switches for such fans shall be located in a group.

3.512.6.3.6 The Main Machinery Room and Auxiliary Machinery Room shall each have a supply and exhaust fan motor controllers electrically interlocked through a single remote switch to provide simultaneous operation of both fans. The controllers shall have independent control so that one fan can be stopped while the other continues.

3.512.6.3.7 Provide the Damage Control Monitoring Panel with single pushbutton switches for each Damage Control Classification in each firezone. Switches are to emergency stop for all Class Circle W supply and exhaust ventilation fans, except for fans that serve spaces in which HALON 1301 fire protection systems are installed.

3.512.7 Shock Requirements. Ventilation systems that are classified W or Circle W, and all components of these systems, except those components noted in this paragraph shall meet shock requirements as defined in Section 3.072.

3.517 <u>Waste Heat and Jacket Water</u>

3.517.1 Waste Heat Recovery System General Requirements. The existing Waste Heat Recovery System shall be removed prior to or concurrently with engine replacement by shipalt MCM1-301D for MCM10 through MCM14, and shipalt MCM1-26K revision 1, increment 2 for MCM1 through MCM9. As a result, no work on this system shall be required by this contract.

3.517.2 Jacket Water General Requirements. The Jacket Water system mounted separately from the removed engines shall be removed without replacement to accommodate engine replacements. Removal shall include jacket water expansion tank, tubing, hoses, valves, cabling, instruments and associated components. New engines shall be supplied with self-contained jacket water system in accordance with the Technical Specification for MPDE and SSDG Engine Retrofit Application for MHC51 and MCM1 Class Ships. All removed valves and instruments shall be turned over to local item manager for disposition.

3.534 Gravity Drain Collection System

3.534.1 Definitions.

a) Oily Waste – Water drains from ship's systems containing approximately 1% oil.
b) Waste Oil – Oil drains from ship's systems containing approximately 99% oil.
c) Waste Water – Water drains from ship's systems not containing oil.

3.534.2 General Requirements. Following are performance requirements for the gravity drain collection system. The existing ship's system shall be reconfigured to accommodate engine replacements. Oily waste drain collection system shall collect all oily waste and waste oil drains of each installed diesel engine via funnel or drip pan and deliver it to the existing collection tank. All other drains shall be routed to waste water drain system. System shall meet shock requirements of Section 3.072. System shall meet requirements of Section 3.505 and as follows.

3.534.3 Arrangement. Oily waste drain collection system shall not collect non-oil type fluids. Waste water collection system shall collect non-oil type fluids. Reconfigured system shall be arranged to avoid unequal pressures between connecting branch lines. Drains shall not open to the bilge. To reduce the number of drain main connections, a common funnel may receive the discharge from two or more sources. System piping runs shall maintain a slope of ½" per foot with respect to ship's normal trim.

3.534.3.1 Reconfiguration Boundaries. Reconfiguration of gravity drain collection system shall be limited to the piping between the existing engine funnels to the next tee branch in the system. Existing funnels shall be utilized to the maximum extent possible.

3.534.3.2 Interface. Existing oily waste system piping is Copper Nickel Alloy 90/10, class 200, between ¼ and 1 nps.

3.534.4 Components. All components installed serving any one engine shall be 100% interchangeable with those installed on the other engines. All components and material used in gravity drain systems shall be capable of operating in the system design temperatures and pressures of 150 degrees F (66 degrees C) at atmospheric pressure

3.534.4.1 Sample Connections. Sample connections shall be located for convenience of sampling over a funnel or drip pan. Distance between sample point and collection funnel or drip pan shall accommodate sample bottle.

3.534.4.2 Valves. Each funnel branch shall contain a check valve. Check valves shall be installed low enough below its associated funnel to allow free flow from the funnel. Installation of valves shall be such that ship movement does not compromise the valve's operation. Other than a swing check valve preventing backflow, piping shall not contain any isolation valves.

3.534.4.3 Funnels. Funnels shall be sized a minimum of one pipe size larger than the total of all pipe sizes emptying into it. Maximum number of pipes expected to be emptying at any one time shall be used for sizing funnel. Funnels shall not allow splash outside the funnel during operation. Funnels shall be protected from foreign material entry. Funnels shall be located where they can be readily observed by operating personnel.

3.534.5 Operation. System design shall allow free flow of drains from all funnels to the collection tank without overflow of any funnels. System shall be capable of removing the maximum amount of liquid expected under any operating condition, and be designed and constructed to minimize the possibility of becoming plugged by scale or dirt accumulations.

3.534.6 Quality Assurance and Cleaning Requirements. The oily waste collection system shall meet the cleanliness and testing criteria specified in Sections 3.095 and 3.505, respectively.

3.541 Fuel Oil Service System

3.541.1 Definitions.

a) F-76 – Diesel fuel in accordance with MIL-F-16884.
b) JP-5 – Fuel in accordance with MIL-DTL-5624.

3.541.2 General Requirements. Following are performance requirements for Fuel Oil Service System. The existing ship's system shall be reconfigured to accommodate engine replacements. Fuel oil service system shall deliver F-76 or JP-5 from the service tank to each installed diesel engine for combustion, and return unused fuel back to the service tank. All components installed serving any one engine shall be 100% interchangeable with those installed on the other engines. System shall meet shock requirements of Section 3.072. System shall meet requirements of Section 3.505 and as follows.

3.541.3 Arrangement. Fuel oil service system shall be arranged for maximum protection against impingement on hot surfaces and electrical equipment in accordance with Section 3.505. Drain, vent and test connections shall be led to the oily waste drain collection system in accordance with Section 3.534. Fuel supply system shall be arranged to provide positive suction head.

3.541.3.1 Reconfiguration Boundaries. Reconfiguration of fuel oil service system shall be limited as follows:

a) MPDE and SSDG Fuel Supply (MCM1 – 14) – From the existing engine connections to a point no further than the supply isolation valve. See Figures 12 and 13.
b) MPDE and SSDG Fuel Return (MCM1 – 2) – From the existing engine connections to a point no further than the return 3-way ball valve. See Figure 12.
c) MPDE and SSDG Fuel Return (MCM3 – 14) – From the existing engine connections to a point no further than the return check valve. See Figure 13.

3.541.3.2 Interface. Reconfigured system shall interface as follows to the above boundaries.

3.541.3.2.1 MCM1 through MCM14:

a) Main Propulsion Diesel and Ship Service Diesel Generator Fuel Supply – ¾" nps, CRES 304L, schedule 10.
b) Main Propulsion Diesel and Ship Service Diesel Generator Fuel Return – ½" nps, CRES 304L, schedule 10.

3.541.4 Components. All components and material used in fuel systems shall be capable of operating in the system design temperatures and pressures as follows:

a) Fuel Supply – ambient temperature at 50 psig
b) Fuel Return (after cooler) – 140 degrees F (60 degrees C) at 5 psig (34.5 kPa)

3.541.4.1 Valves. Other than a swing check valve preventing backflow of fuel to a stopped engine, fuel return piping shall not contain any positive shut-off valves, upstream of existing return line relief valve.

3.541.4.2 Fuel/Water Separators. Fuel/Water Separators shall comply with "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships."

3.541.4.3 Joints. Brazed and union joints shall not be utilized as discussed in Section 3.505. Mechanically Attached Fittings (MAF), welded, and flanged joints are allowed and shall comply with Section 3.505. Flange joints shall be minimized consistent with that required for maintenance purposes. Flange joints shall have spray shields in accordance with NAVSEA standard drawing 803-2145518.

3.541.4.4 Fuel Oil Return Coolers, MCM3 through MCM14. If coolers are not provided with engine, existing coolers shall be retained. Seawater cooling to the coolers shall comply with Section 3.256. Coolers shall keep returned fuel below 140 degrees F (60 degrees C) or that recommended by the engine manufacturer, whichever is less.

3.541.4.5 Fuel Oil Return Coolers, MCM1 and MCM2. If coolers are not provided with engine, they shall be separately installed in the return fuel piping from the engine. Seawater cooling to the coolers shall comply with Section 3.256. Coolers shall keep returned fuel below 140 degrees F (60 degrees C) or that recommended by the engine manufacturer, whichever is less.

3.541.5 Operation*.* The following flow conditions shall be demonstrated by formal engineering calculations in accordance with Section 3.505.

3.541.5.1 MCM1 – 14 Flow. Reconfigured piping system shall allow the existing fuel oil system capacities of 2.5 gpm (9.5 lpm) at ambient temperature of F-76 or JP-5 to each engine's attached fuel pump when at full power. Return fuel system shall allow existing capacity of 1.4 gpm (5.3 lpm) at 140 degrees F (60 degrees C) of F-76 or JP-5 to fuel oil service tanks. Reconfigured fuel piping system shall not allow system fluid to exceed the velocity limits of Section 3.505. Complete system shall provide sufficient flow and pressure to allow each engine to operate over its full range of operating parameters.

3.541.5.2 MCM1 – 14 Pressure Requirements. During all engine operating conditions, system pressure upstream of attached fuel pump and in return piping shall not exceed 5 psig (34 kPa). Return piping system shall not exert back pressure on engine beyond the limits specified in "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships."

3.541.6 Quality Assurance and Cleaning Requirements. The fuel oil system shall meet the cleanliness and testing criteria specified in Sections 3.095 and 3.505, respectively.

3.551 <u>Compressed Air System</u>

3.551.1 General Requirements. Following are performance requirements for compressed air. The existing ship's system shall be reconfigured to accommodate engine replacements. Reconfigured starting air system shall deliver compressed air to each installed diesel engine for engine starting. System shall meet shock requirements of Section 3.072. System shall meet the requirements of Section 3.505 and as follows.

3.551.2 Arrangement. Piping shall be arranged to eliminate pockets where moisture may collect. Where pockets or low points are unavoidable, drains shall be provided.

3.551.2.1 Reconfiguration Boundaries. Reconfiguration of compressed air system shall be limited as follows. See Figure 14.

a) MPDE Compressed Air Supply – From the existing engine connections to a point no further upstream than the engine start cutout ball valves.
b) 1A & 1B SSDG Compressed Air Supply – From the existing engine connections to a point no further upstream than the far end of the flex hose.
c) 2 SSDG Compressed Air Supply – From the existing engine connections to a point no further upstream than 2 SSDG start cutout ball valve.

3.551.2.2 Interface. Reconfigured system shall interface as follows to the above boundaries.

a) MPDE Compressed Air Supply – 1¼", bronze, 700 psi SB ball valve
b) 1A & 1B SSDG Compressed Air Supply – 1½" MF37 hose adapter
c) 2 SSDG Compressed Air Supply – 1¼", bronze, 700 psi SB ball valve

3.551.3 Components.

3.551.3.1 General. All components and material used in the compressed air system shall be capable of operating at the system design temperatures and pressures as follows.

a) Starting Air – 150 degrees F (66 Degrees C) at 175 psig (1210 kPa)

3.551.3.2 Valves and Components. Air systems shall be provided with means for bleeding down for repair purposes.

3.551.3.2.1 Starting air panels, control valves, pressure switches and associated piping, removed and/or relocated as a result of engine replacement, shall be installed in the "as-built" configuration except as modified to meet the requirements of "Technical Specification – Main Propulsion and Ship Service Diesel Engine – Retrofit Application for MHC-51 and MCM-1 Class Ships."

3.551.3.2.2 MPDE starting air reducing manifolds, requiring relocation as a result of engine replacement, shall have relief valve setting tested in accordance with NSTM S9086-RK-STM-010/Ch. 505. Discharge piping from relief valves shall be directed so as not to damage machinery or equipment, or endanger personnel.

3.551.3.3 Drains. Drain line terminals shall be located so that the discharge is clearly visible to the operator of the drainage valve.

3.551.4 Operation.

3.551.4.1 Flow. Air piping delivery rates shall meet the demands of the equipment served. Reconfigured compressed air piping system shall not allow system fluid to exceed the velocity limits of Section 3.505. Complete system shall provide sufficient flow and pressure to allow air start system to operate over its full range of operating parameters. These flow conditions shall be demonstrated by formal engineering calculations in accordance with Section 3.505 and operational testing in accordance with Section 3.095.

3.551.5 Quality Assurance and Cleaning Requirements. The compressed air system shall meet the cleanliness and testing criteria specified in Sections 3.505 and 3.095, respectively

3.622 Floor Plates and Grating

3.622.1 General. Floor plates and gratings shall be modified as necessary for access to machinery and equipment. Unnecessary weight and complication shall be avoided, but the load to be supported, including machinery, overhaul tools and parts, shall be considered in determining the length of span. Extra support shall be provided at points where heavy weight or particularly rough usage is expected.

3.622.1.1 Portable sections of floor plates or gratings shall be hinged and be fitted in areas where access is required below them for periodic inspection of equipment, maintenance, cleaning, or where access is required for operation of valves or other controls. Fasteners shall be of a design that shall not open or come apart by shock or vibration, and be of a material compatible with the section to which they are attached. Sections and fittings shall lie flush and be designed to facilitate lifting by hand.

3.622.2 Floor Plates. Floor plates in machinery spaces shall meet the following criteria:

a) Minimum thickness, inches (mm):	0.375 (9.5)
b) Flexural strength (minimum), psi (kPa):	20.50 (141.34)
c) Flexural modulus (minimum), psi (kPa):	1.2×10^6 (8.3×10^6)
d) Barcol hardness:	55
e) Flame spread (ASTM E84):	Less than 25
f) Smoke density, flaming mode (ASTM E84):	Less than 100
g) Color pigmentation:	Equivalent to Formula 23, Red Deck, Color Number corresponding to FED-STD-595 and MIL-E-24635.

3.622.3 Handrails. Handrails in machinery spaces shall be modified as necessary around elevated platforms and gratings, walkways, passageways, and moving parts of machinery.

3.622.3.1 Handrails shall be similar to those shown on Drawing Nos. 101-860039 and 101-860040, firmly secured but readily removable. In machinery spaces, bolted connections may be used instead of the methods of attachment shown on the drawings, provided that the handrails are firmly secured and the necessary portability is ensured.

3.622.3.2 Stanchions supporting handrails shall be perpendicular to the walking level, where practicable. The lower ends shall pass through the walking surface and be secured from below, or the ends shall be provided with flanges and bolted to a secure seating.

3.624 Doors, Hatches, Bolted Equipment Removal Plates

3.624.1 All doors, hatches, and bolted equipment removal plates (BERP) removed for engine installation shall be reinstalled with new sealing gaskets conforming to MIL-R-900.

3.631 Painting

3.631.1 General. This section contains requirements for painting and preservation of new, modified or repaired structure, equipment and materials. When authorized, surface preparation and painting shall be in accordance with NSTM S9086-VD-STM-000/Ch. 631. No flexible hoses, resilient mounts, rubber bushings, hose fittings, valve stems, grease fittings, gauges, and internal engine lubricating oil and fuel passages shall be painted.

3.631.1.1 When NSTM S9086-VD-STM-000/Ch. 631 is referenced in this section, all safety precautions, paint or preservative application procedures, and further documents referenced in NSTM S9086-VD-STM-000/Ch. 631 are hereby invoked.

3.631.1.2 Upon completion of diesel engine installation, paint work shall be complete and in a serviceable condition. Coated surfaces shall show no film failures; that is, loss of adhesion, blistering, rusting, pinholing, checking, cracking, runs or sags greater than 1 percent of any 10 square yards (9 square meters). The materials required shall be furnished and repainted, as necessary, to obtain this result.

3.631.1.3 Where a primer or epoxy primer is specified herein, it shall be MIL-DTL-24441C, Formula 150.

3.631.1.4 Where film thickness is specified, it shall be Dry Film Thickness (DFT), except as otherwise noted in this section.

3.631.1.5 Where the word "blast" or a derivative thereof is specified without other specific instructions as to the degree of surface preparation required, it shall be a near-white metal blast (SSPC-SP 10) as defined by NSTM S9086-VD-STM-000/Ch. 631.

3.631.2 Materials. Materials shall conform to NSTM S9086-VD-STM-000/Ch. 631. The materials shall be furnished and conformance of the paints to be used to the applicable specification requirements shall be certified. Coatings selected for repainting shall be compatible with existing coatings.

3.631.3 Applications. At least two coats shall be applied to satisfy all requirements for minimum film thickness except where one coat is specifically permitted. Unless otherwise specified, after the first coat has been applied, subsequent coats shall not be applied until the preceding coat has become properly dry. The dry film shall be free of surface contaminants including moisture. Before the application of any coat, all bare spots on the preceding coat shall be "touched-up."

3.631.3.1 A full "dress-up" coat is not classified as touch-up. Where repairs are made and completed by welding, burning, chipping or grinding, the affected areas are to be touched-up with paint to match the surrounding area in accordance with NSTM S9086-VD-STM-000/Ch. 631.

3.631.4 Surface Preparation (Metal, Plastic and Wood). Surface preparation shall be as specified in NSTM S9086-VD-STM-000/Ch. 631 or as further directed in this or other sections herein.

3.631.4.1 Priming coats shall be applied as soon as practicable after surface preparation, but in no instance longer than 24 hours.

3.631.4.2 All surfaces shall receive at least one priming coat after surface preparation. Exterior surfaces shall also receive a complete second coat of primer, where specified.

3.631.4.3 Precautions shall be taken to protect machinery, equipment and structure from abrasive damage, and to prevent contamination and spread of abrasives and dust.

3.631.4.4 For aluminum surfaces that require abrasive blasting prior to painting, the surfaces should be blasted with aluminum oxide grit or garnet grit. For surfaces in a fit-for-use condition, such as new plates with primer coats, blasting may be eliminated and the surfaces only solvent wiped to remove surface contamination prior to painting.

3.631.5 Pre-treatment and Priming (Metal and Plastic). Pre-treatment and priming coats shall be applied as soon as practicable after surface preparation, but in no instance longer than 24 hours.

3.631.5.1 Formula 84D may be used in lieu of Formula 84 to provide color contrast. Primers shall be applied to a minimum dry film thickness of 1 mil.

3.631.5.2 The original priming coat, touched-up as required, shall constitute the first coat of primer where one or more coats are specified.

3.631.5.3 All interior surfaces shall receive at least one priming coat.

3.631.5.4 Plastic Surfaces (where painting is required to provide correct color). In order to remove residual mold release compounds, glass-reinforced or other plastic surfaces shall be washed with a mixture of water and liquid detergent cleaner, MIL-D-16791, type I, then rinsed with clean fresh water, then wiped with xylene, BSMI K1009300. After washing, the surface shall be lightly abraded in such a way that the surface is only slightly roughened, and the glass underlay is not exposed. Dust shall be removed before painting. Surfaces to be painted shall receive one coat of Formula 150.

3.631.5.4.1 Unless otherwise specified, interior surfaces of aluminum alloy that are to be painted shall be given one coat of Formula 150, or be chemically cleaned and given one coat of Formula 84. The following interior surfaces shall not be painted when constructed of aluminum alloy, but items enclosed in parentheses shall be finished with a clear lacquer or waxed:

a) Frames and stanchions of pipe berths
b) Gratings, (hand rails), and upper surfaces of floor plates

3.631.6 Interiors. Interior surfaces shall be painted and preserved in accordance with NSTM S9086-VD-STM-000/Ch. 631, except as noted herein.

3.631.6.1 Insulation. Fibrous glass board shall be painted with one coat of chlorinated alkyd paint to match surrounding structure. Unicellular type insulation shall be coated with a three coat Ocean Chemical Co., one coat Ocean 634 at 1-2 mils DFT and two coats Ocean 9788 at 5 mils DFT per coat, system or other NAVSEA approved flexible coating system.

3.631.6.1.1 The surfaces behind the insulation should receive two coats of Formula 150.

3.631.6.2 Fire zone bulkheads. Uninsulated surfaces of fire zone bulkheads on or above the main deck shall be primed with one coat of primer (Formula 150), then coated with two coats of paint, (MIL-C-46081) to a dry film thickness of 10 to 13 mils.

3.631.6.3 Acoustical absorptive treatment. New or disturbed acoustical absorptive treatment shall be painted with one coat of paint (two coats, if required for hiding) to match surrounding structure. The paint shall be sprayed on in thin coats and care shall be taken to avoid bridging or sealing the perforations in the sheathing or facing of the treatment with paint.

3.631.6.4 Chlorinated alkyd paints may be applied over clean, dry, existing primer (Formula 84 or 150) that has been touched up as necessary. Touch-up painting shall cure 48 hours before topcoating.

3.631.6.5 If necessary for satisfactory hiding, additional coats of finish paint shall be applied. Six hours drying time shall be allowed between coats.

3.631.6.6 Surfaces that are to be sheathed, shall be primed and finish painted with Formula 124 before being closed in.

3.631.6.7 Unless otherwise specified, all interior decks shall be coated with three coats of an epoxy system, which includes the primer, conforming to MIL-DTL-24441C, to a minimum total film thickness of 6 mils. Unless otherwise specified, the final coat should be Formula 151 or pigmented to match the color of Formula 20. Before painting, decks shall be abrasively cleaned to bare metal and solvent cleaned to remove grease, oil and other contaminants.

3.631.6.8 Surfaces that shall be inaccessible for painting after assembly shall be coated with primer and finish coat before assembly.

3.631.6.9 Surfaces requiring primer coat shall also have one finish coat, Formula 111, class 2.

3.631.6.10 Surfaces of front panels shall be given a second finish coat, Formula 111, class 2. These surfaces shall be smooth and free of nicks, scratches and unevenness of finish.

3.631.6.11 All surfaces painted with a finish coat shall be touched up as required.

3.631.7 Machinery and Piping. When machinery and piping are received in an unpainted condition, or if paint is damaged before or during installation, painting shall comply with the requirements of NSTM S9086-VD-STM-000/Ch. 631 except as noted herein.

3.631.7.1 As an alternative, external machinery surfaces and piping may be thermal sprayed with aluminum and painted in accordance with the requirements of Section 630 of the Builder Specification.

3.631.7.2 Painting of thermal insulation shall comply with Section 3.508. Lagging that may be subjected to combustible fluids or hydraulic fluids shall be coated with an epoxy system conforming to MIL-DTL-24441C. Heat-resisting aluminum paint that has not been covered with lagging or thermal insulation shall not be finish painted with a cosmetic coat to match the surrounding compartment. Glass cloth or tape lagging shall be painted the same as surrounding area.

3.631.7.3 Paint shall be excluded from sprinkler heads and heat sensors within magazines.

3.631.7.4 Stenciling and identification painting of piping and valves shall comply with Section 507 of the Builder Specification.

3.635 Thermal, Fire, and Acoustical Treatments of Compartments

3.635.1 Thermal Insulation. The Main Machinery Room and Auxiliary Machinery Room are treated with thermal insulation.

3.635.1.1 Fibrous glass board shall be repaired or replaced in accordance with NAVSEA Drawing No. 805 1749057, except that in lieu of welded studs, another suitable means of fastening, such as nonmagnetic wood screws and caps shall be used. Thermal insulation material shall be faced fibrous glass board conforming to MIL-I-742, Type 1.

3.635.2 Acoustic Absorptive Treatment. The Main Machinery Room, Auxiliary Machinery Room, and Uptake Space are treated with acoustical absorptive insulation Type II and Type III. Replacement or repair shall consist of fibrous glass conforming to MIL-I-22023, Class 6 for

Type II treatment, and 2 inch thick perforated acoustic board conforming to MIL-A-23054 for Type III treatment.

3.635.3 Fire Insulation. Fire insulation treatment is installed in the Auxiliary Machinery Room and the Main Machinery Room. Fire Insulation shall conform to materials specified in NAVSEA drawing No. 804-5184182, except that non-magnetic materials that are capable of withstanding fire for a minimum of 30 minutes shall replace magnetic materials, and that metal sheathing not be used unless it conforms to the magnetic permeability and the electrical conductivity requirements of Section 3.051. The means of fastening the insulation shall be sufficient to hold the insulation in place under shock conditions defined in Section 3.072.

APPENDIX A

MCM1 Class Deliverable Items

- 095-233 (Engine & Systems)– Acceptance Test Records
- Engine_Tech Manual
- System Tech Manual (Update) – For any changes to the system
- Engine POG or similar operational manual
- Provisioning Technical Documents (PTD) for any new system component not stock listed. (Includes: Assembly Drawing, Breakdown Drawing, Part List, Part Numbers, Cost)
- Flushing Test Procedure
- Welding and NDT Procedure
- Exhaust System "Triflex" Results
- Exhaust System Flange Bolting "PC-Bolt" Calculation Results
- **Engineering Drawing**
- SWBS 200, Main Machinery Room Arrangement Modifications
- SWBS 200 , Generator Room No. 1, Arrangement Modifications
- SWBS 200, Generator Room No. 2, Arrangement Modifications
- SWBS 233, Propulsion Engine Installation
- SWBS 233, Propulsion Engine Removal
- SWBS 310, SSDG Engine Installation
- SWBS 310, SSDG Engine Removal
- SWBS 256, Seawater System Modifications Incidental to Propulsion Engine Replacements
- SWBS 256, Seawater System Modifications Incidental to SSDG Replacements
- SWBS 256, Seawater System Removals Incidental to Propulsion Engine Replacements
- SWBS 256, Seawater System Removals Incidental to SSDG Replacements
- SWBS 256, Seawater System Engineering Calculations
- SWBS 259, Combustion Air and Exhaust Modifications Incidental to Propulsion Eng Replacements
- SWBS 259, Combustion Air and Exhaust Modifications Incidental to Ships Diesel Gen Replacements
- SWBS 259, Combustion Air and Exhaust Removals Incidental to Propulsion Engine Replacements
- SWBS 259, Combustion Air and Exhaust Removals Incidental to SSDG Replacements
- SWBS 259, Combustion Air and Exhaust System Engineering Calculations
- SWBS 262? Integral on Ifs
- SWBS 517, Jacket Water System Removals Incidental to Propulsion Engine Replacements
- SWBS 517, Jacket Water System Removals Incidental to SSDG Replacements
- SWBS 534, Oily Waste Drn Collection Sys Modifications Incidental to Propulsion Eng Replacements
- SWBS 534, Oily Waste Drn Collection Sys Modifications Incidental to SSDG Replacements
- SWBS 534, Oily Waste Drn Collection Sys Removals Incidental to Propulsion Eng Replacements
- SWBS 534, Oily Waste Drn Collection Sys Rmvls Incidental to SSDG Replacements
- SWBS 541, Fuel Oil Svc System Modifications Incidental to Propulsion Eng Replacements
- SWBS 541, Fuel Oil Svc System Modifications Incidental to SSDG Replacements
- SWBS 541, Fuel Oil Svc System Removals Incidental to Propulsion Engine Replacements
- SWBS 541, Fuel Oil Svc System Removals Incidental to SSDG Replacements
- SWBS 541, Fuel Oil Svc System Engineering Calculations

- SWBS 551, Compressed Air System Modifications Incidental to Propulsion Engine Replacements
- SWBS 551, Compressed Air System Modifications Incidental to SSDG Replacements
- SWBS 551, Compressed Air System Removals Incidental to Propulsion Engine Replacements
- SWBS 551, Compressed Air System Removals Incidental to Ships SvcDiesel Generator Replacements
- SWBS 551, Compressed Air System Engineering Calculations

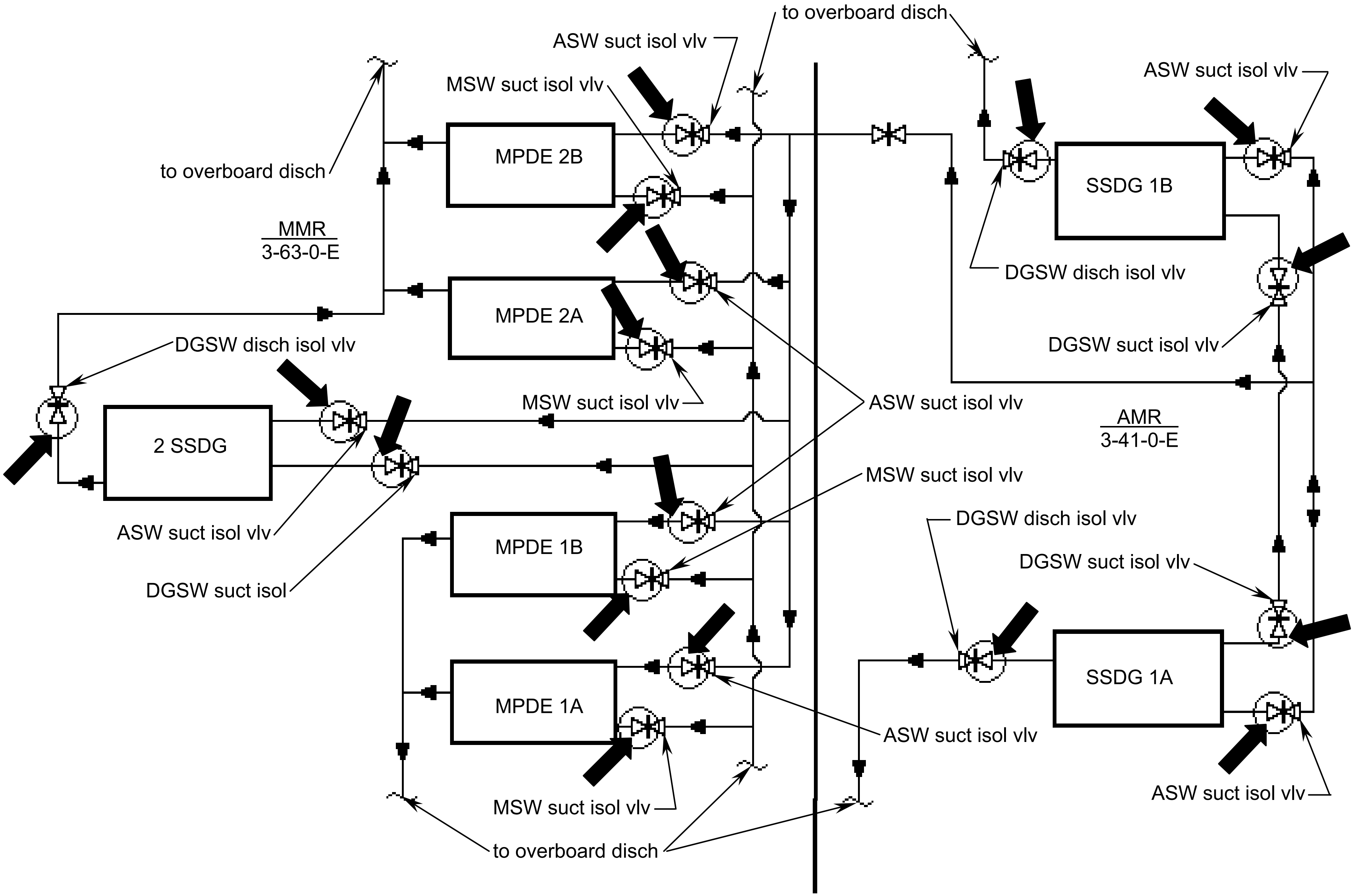

Figure 1
MPDE sply and SSDG Seawater Boundary Diagram

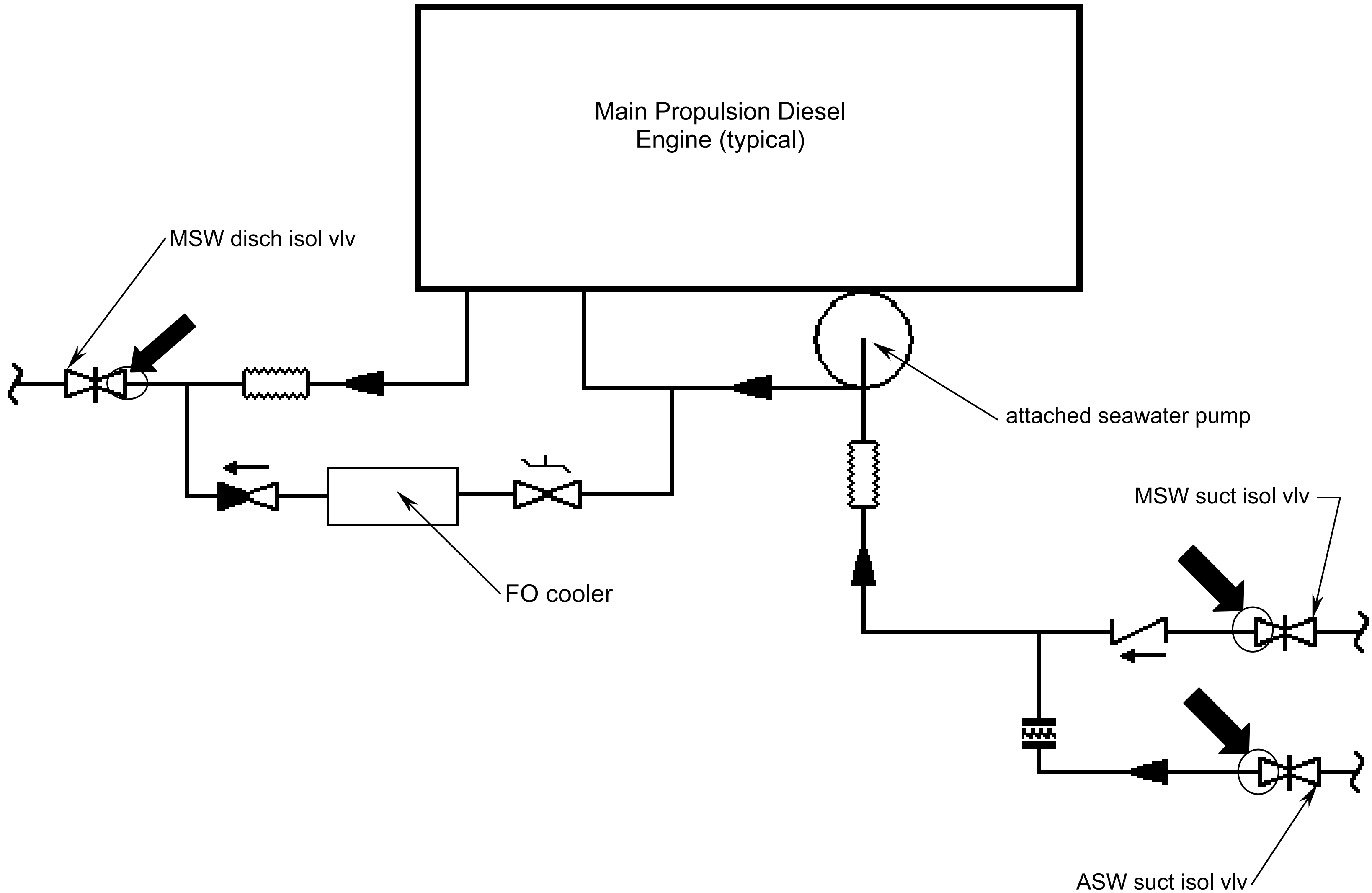

Figure 2
MCM1& 2 MPDE Seawater Discharge Boundary Diagram

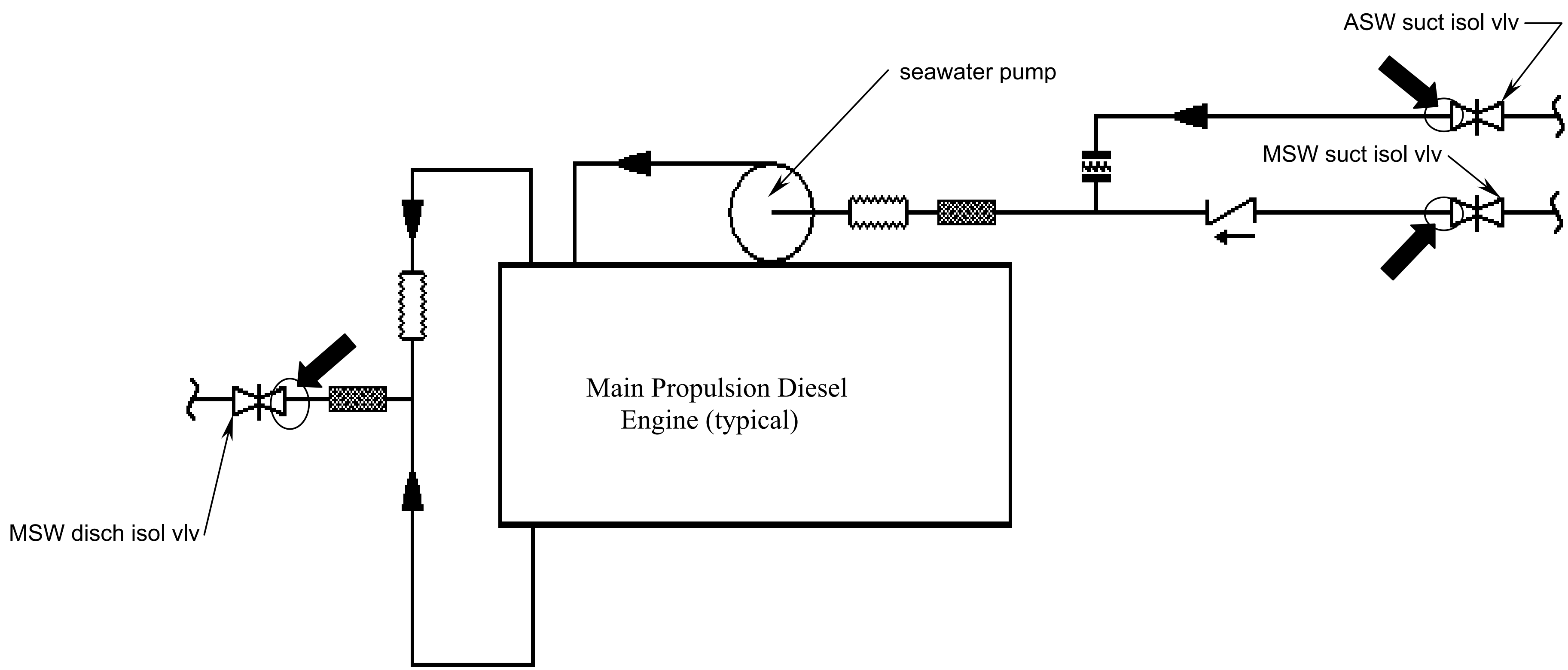

Figure 3
MCM3 – 14 MPDE Seawater Discharge Boundary Diagram

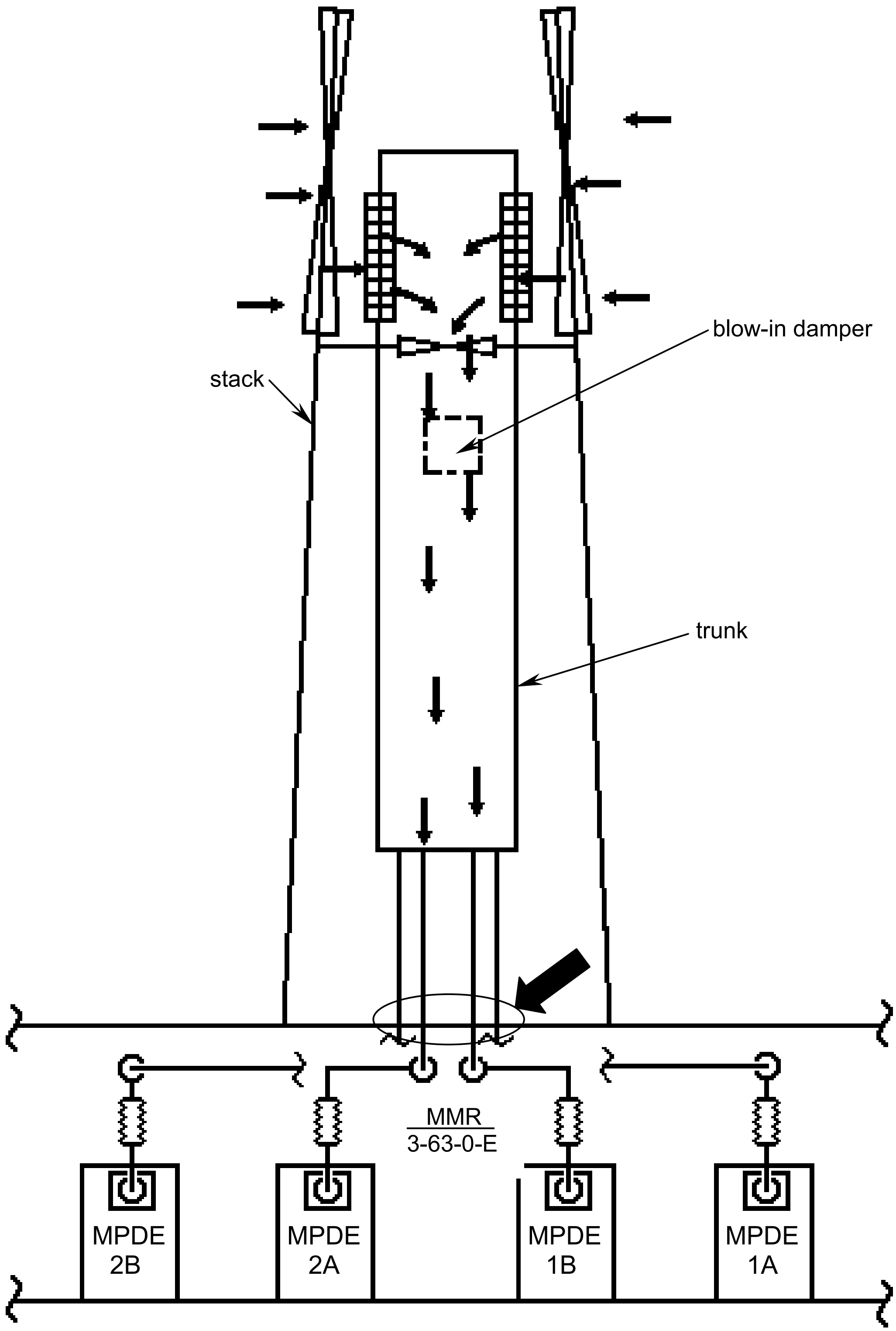

Figure 4
MCM1 & 2 MPDE Combustion Air Boundary Diagram

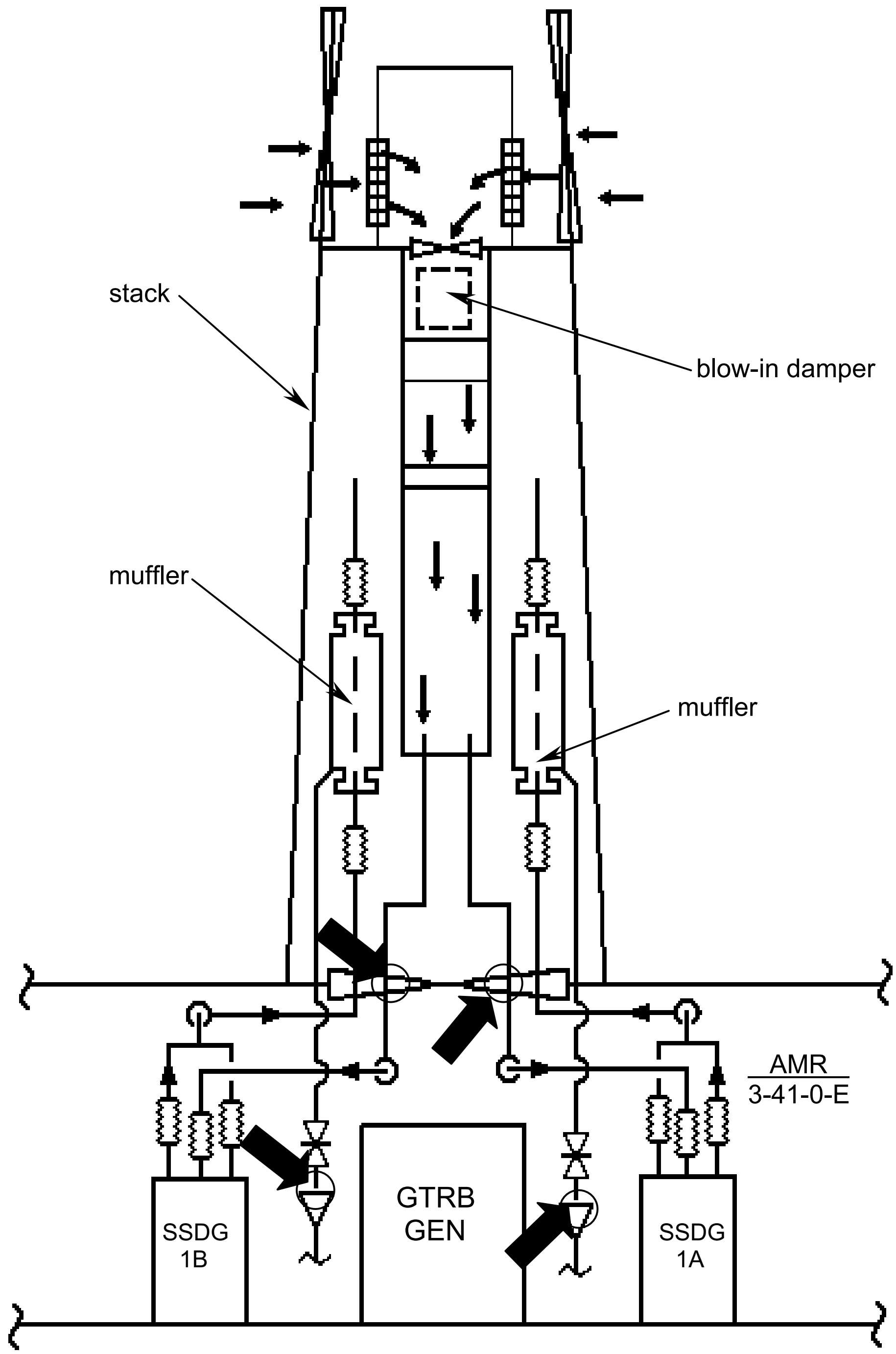

Figure 5
MCM1 & 2 SSDG Combustion Air and Exhaust Boundary Diagram

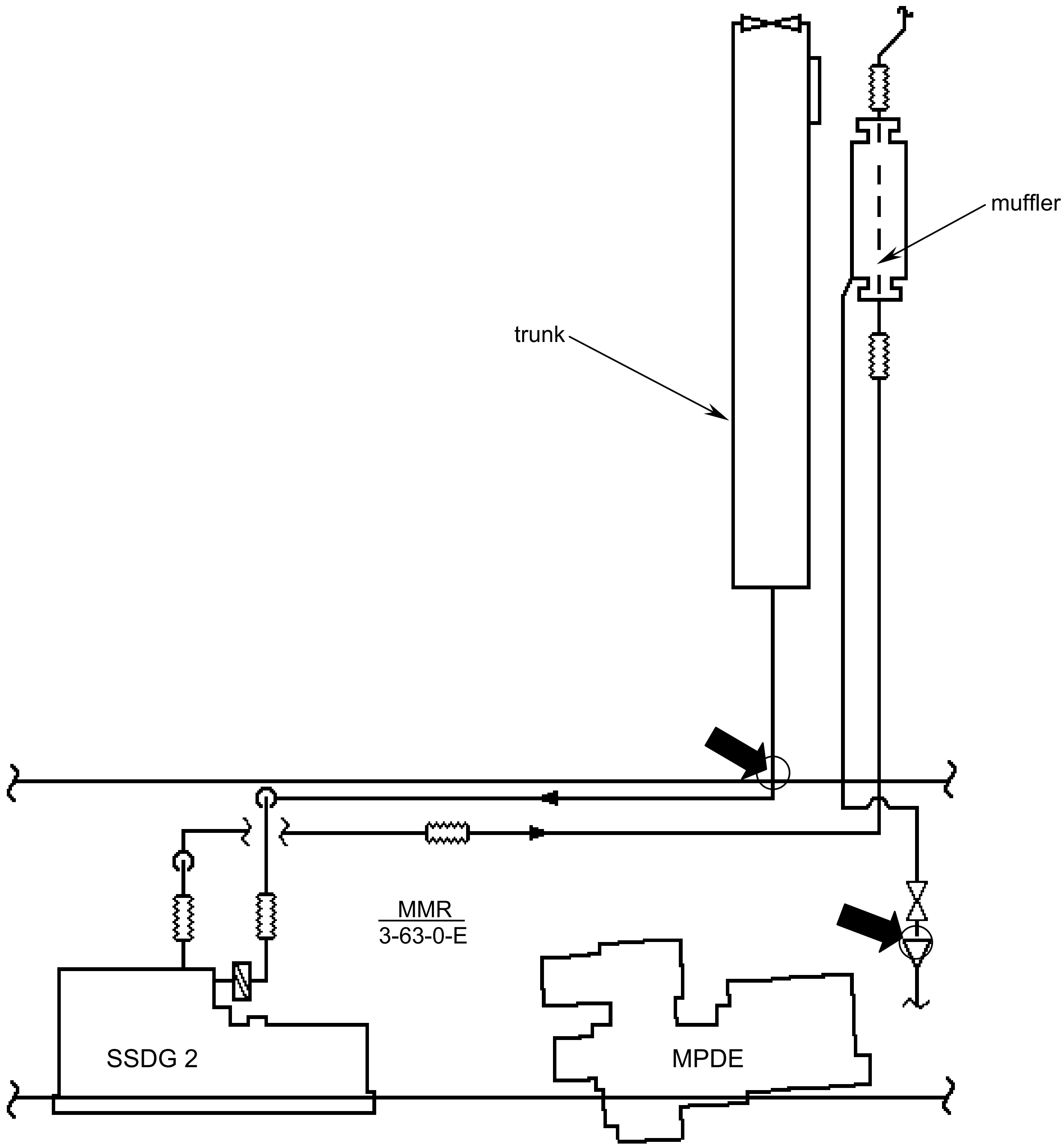

Figure 6
MCM1 & 2 SSDG 2 Combustion Air and Exhaust Boundary Diagram

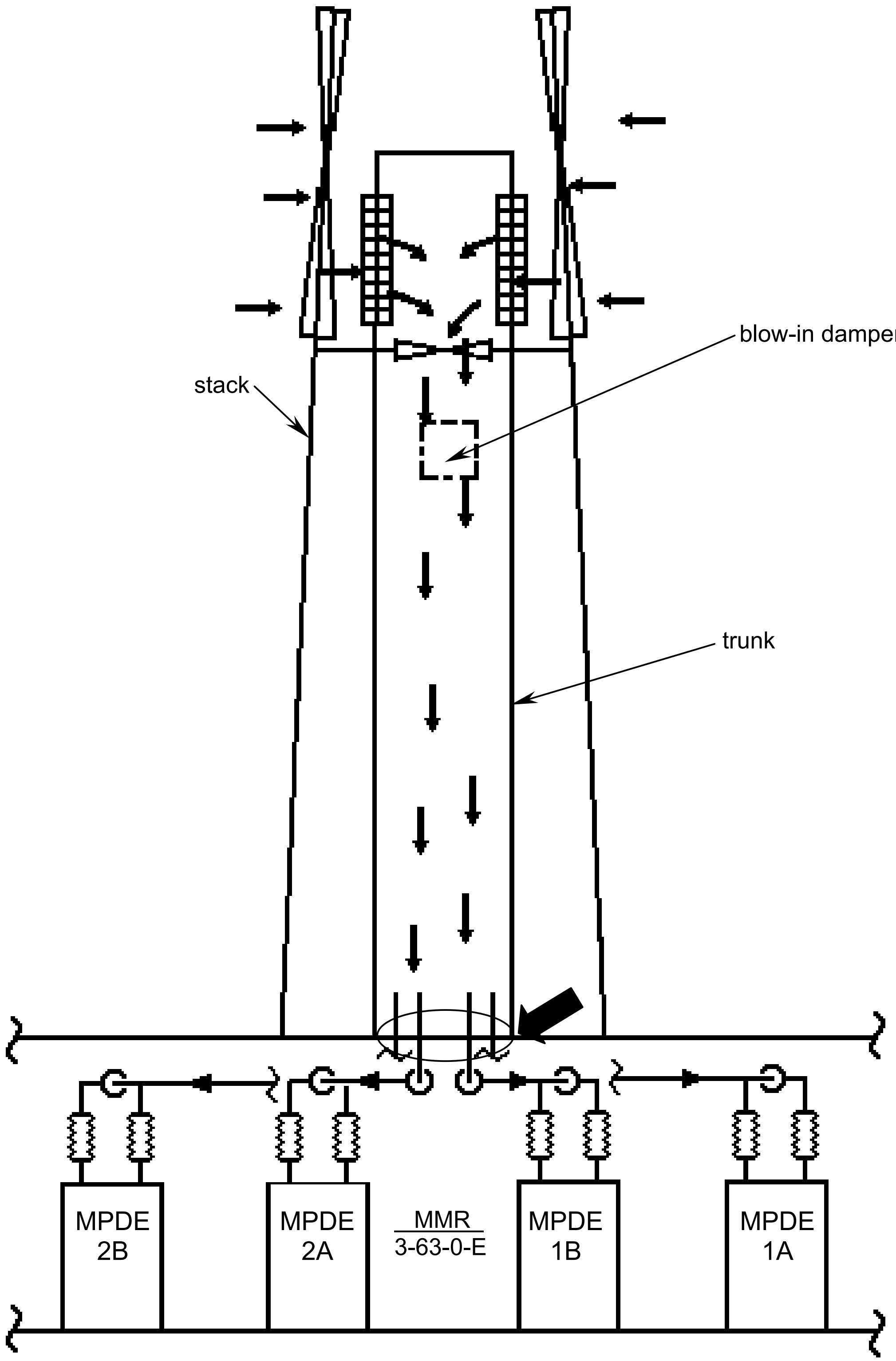

Figure 7
MCM3 - 14 MPDE Combustion Air Boundary Diagram

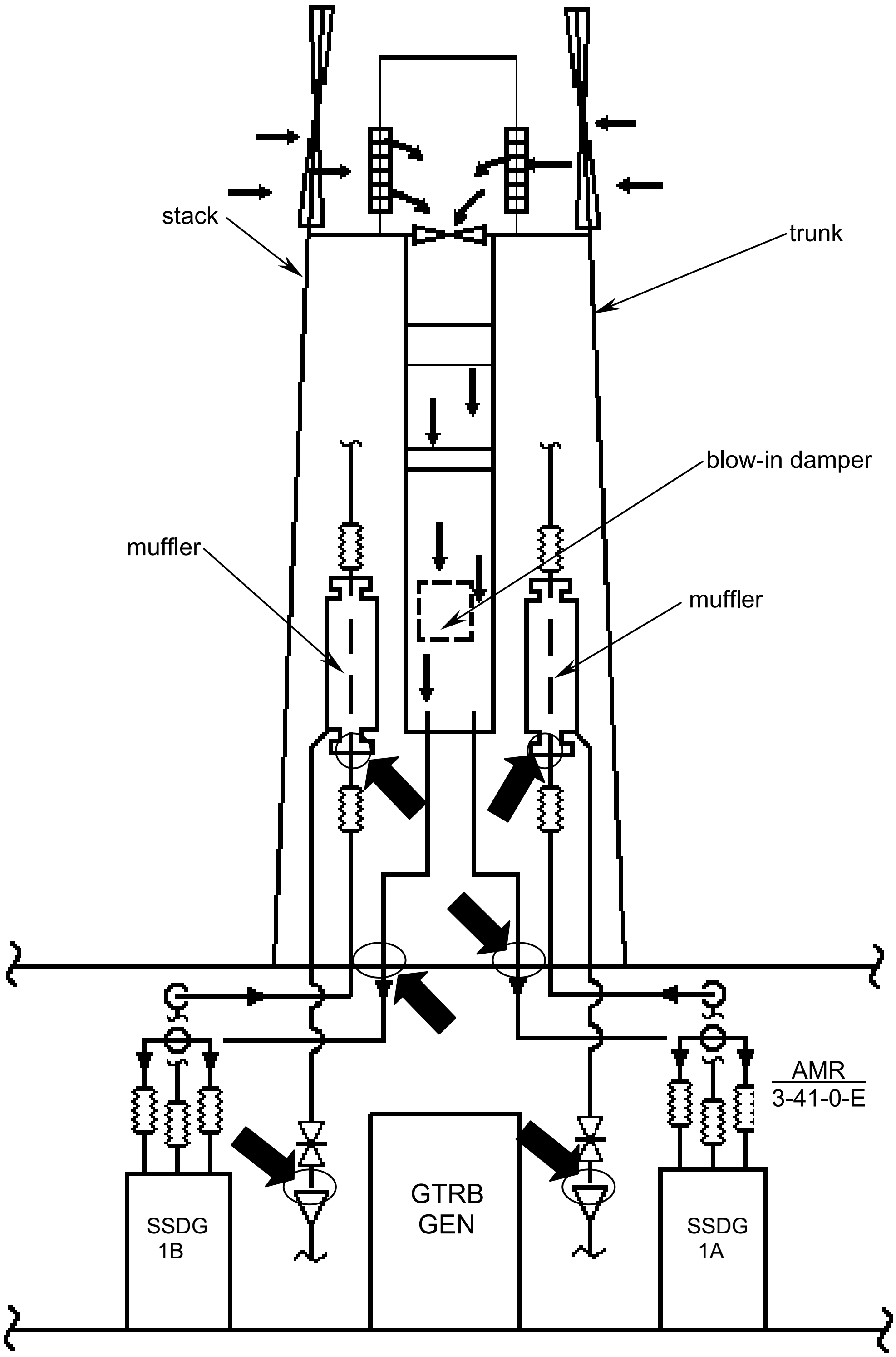

Figure 8
MCM3 - 14 SSDG Combustion Air and Exhaust Boundary Diagram

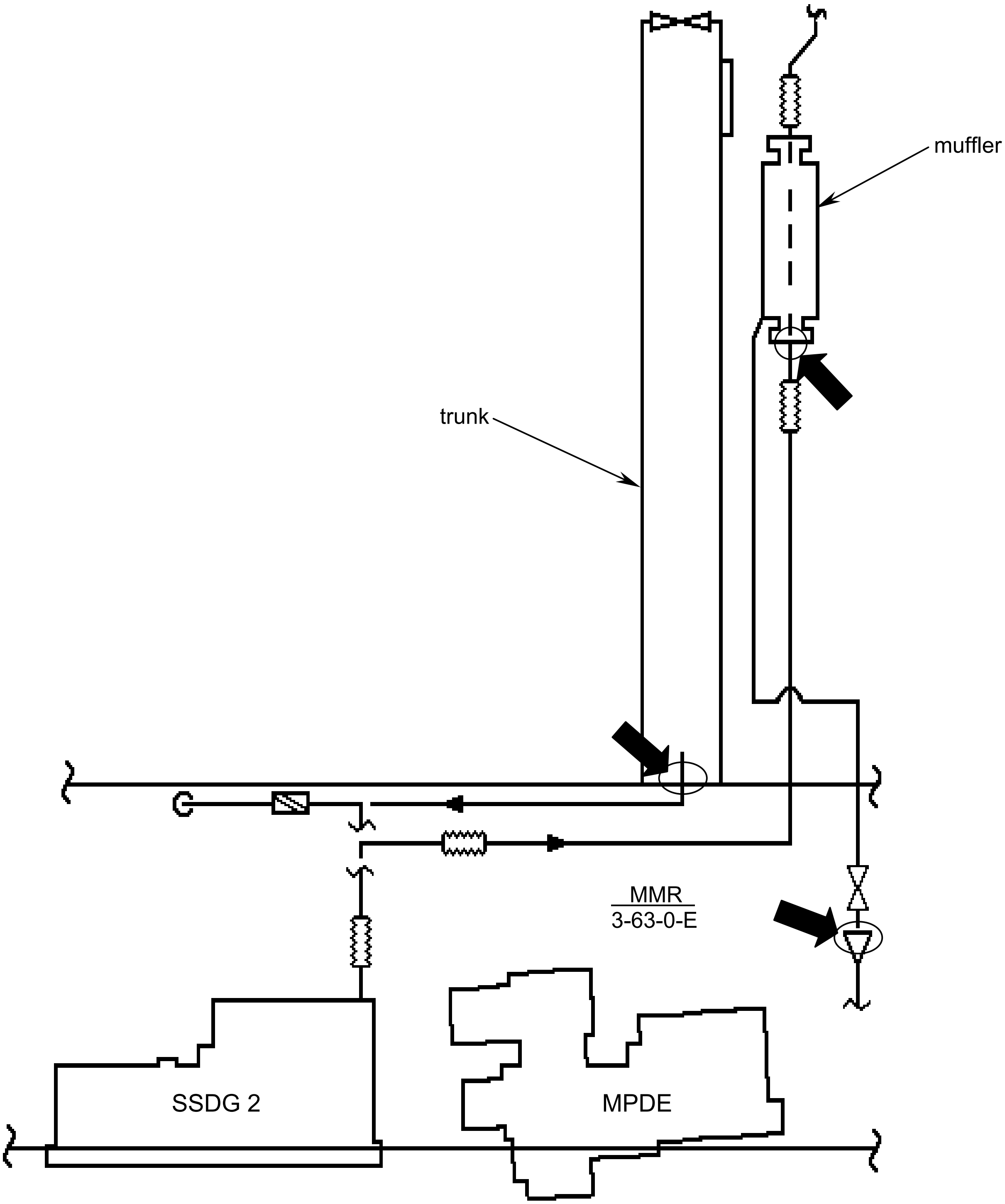

Figure 9
MCM3 – 14 SSDG 2 Combustion Air and Exhaust Boundary Diagram

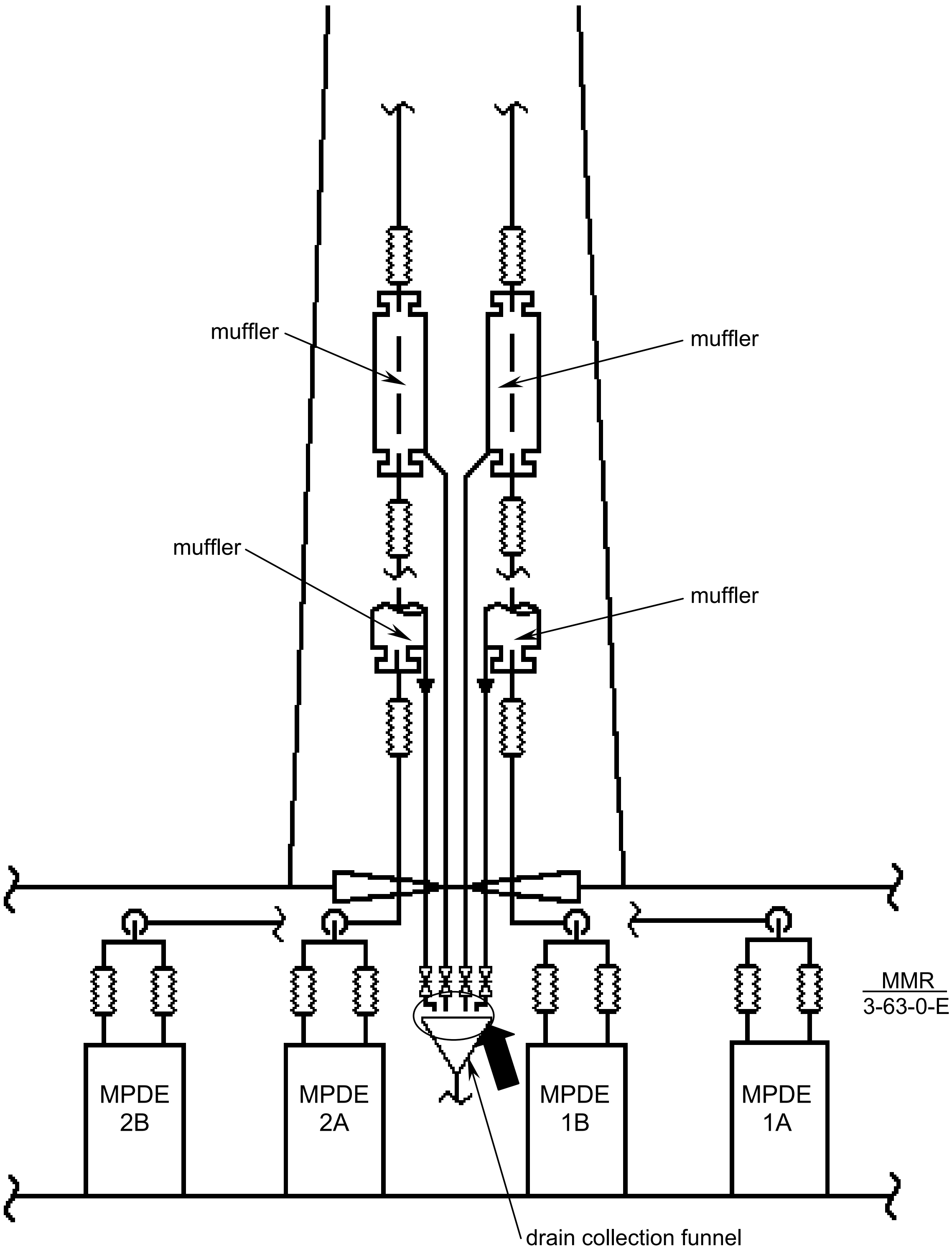

Figure 10
MCM1 & 2 MPDE Combustion Exhaust Boundary Diagram

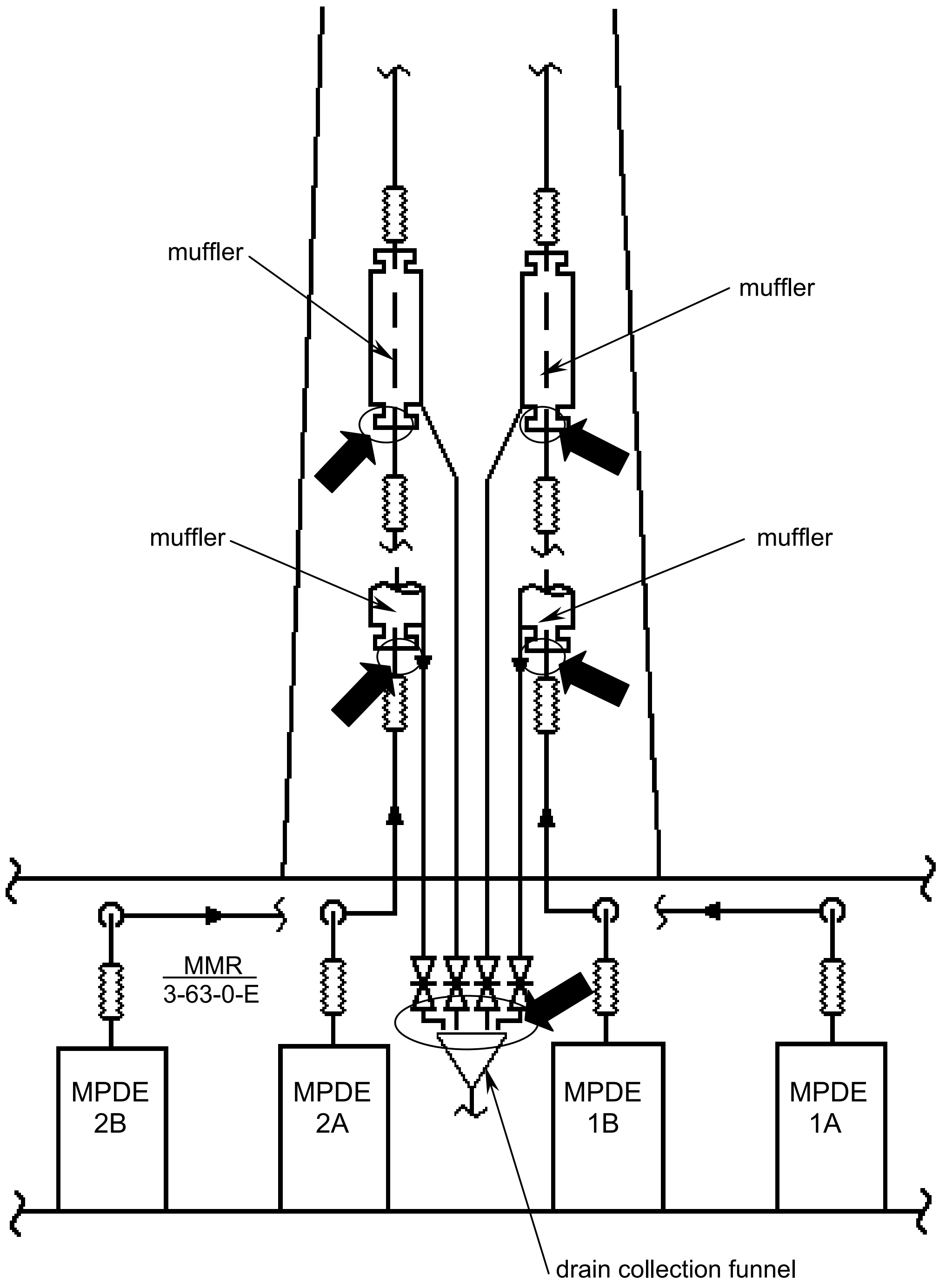

Figure 11
MCM3 - 14 MPDE Combustion Exhaust Boundary Diagram

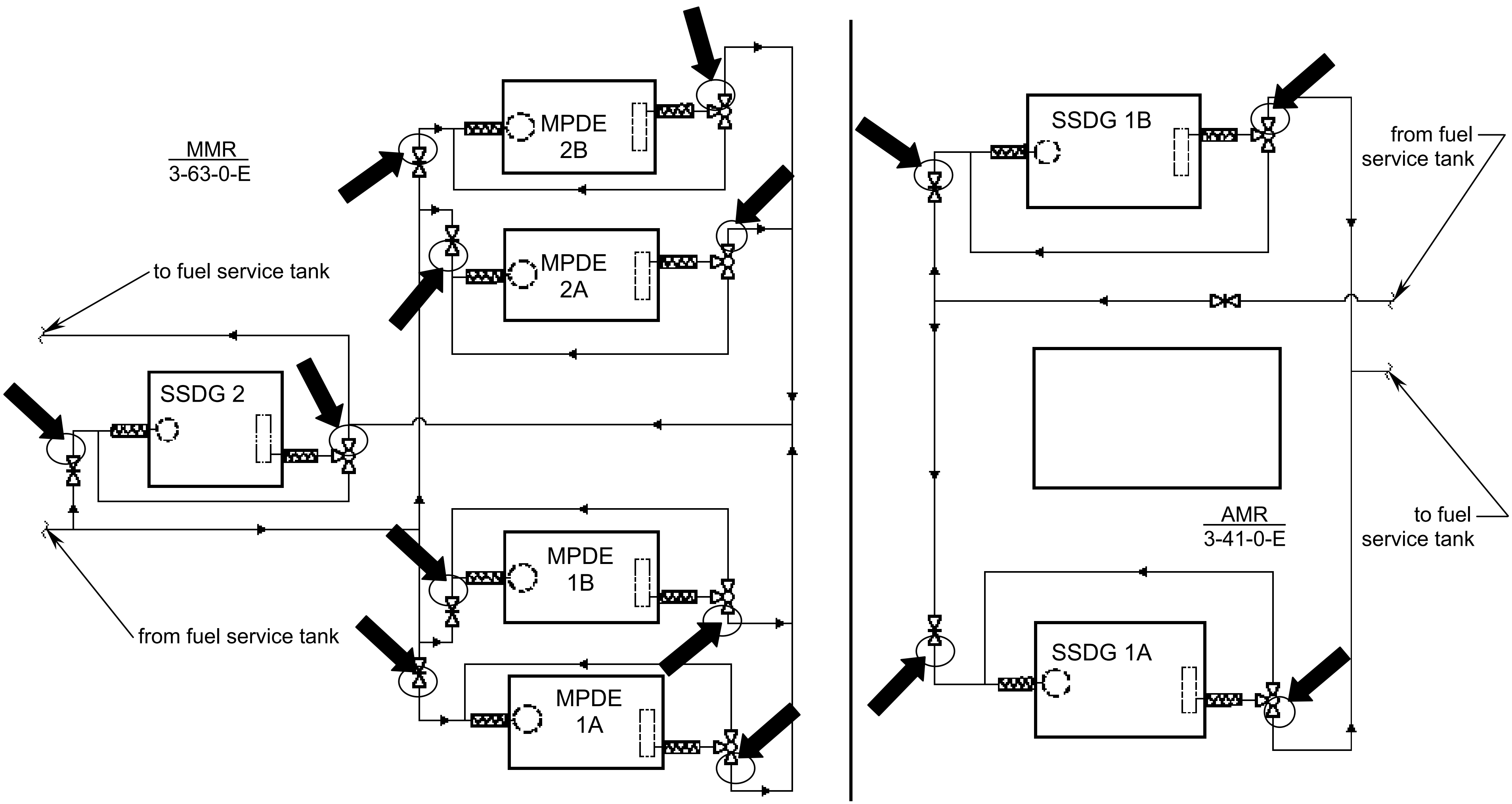

Figure 12
MCM1 & 2 Fuel System Boundary Diagram

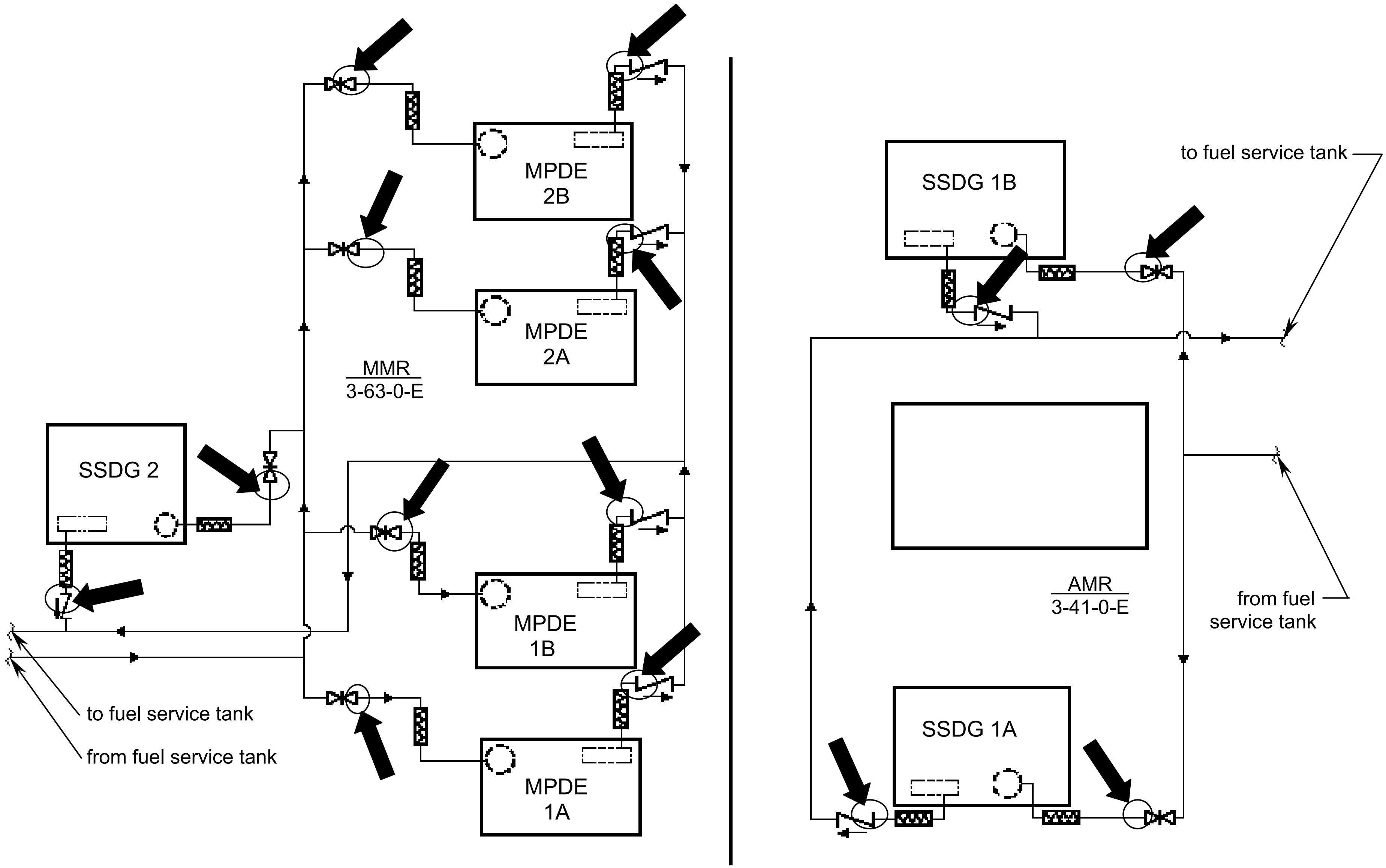

Figure 13
MCM3 - 14 Fuel System Boundary Diagram

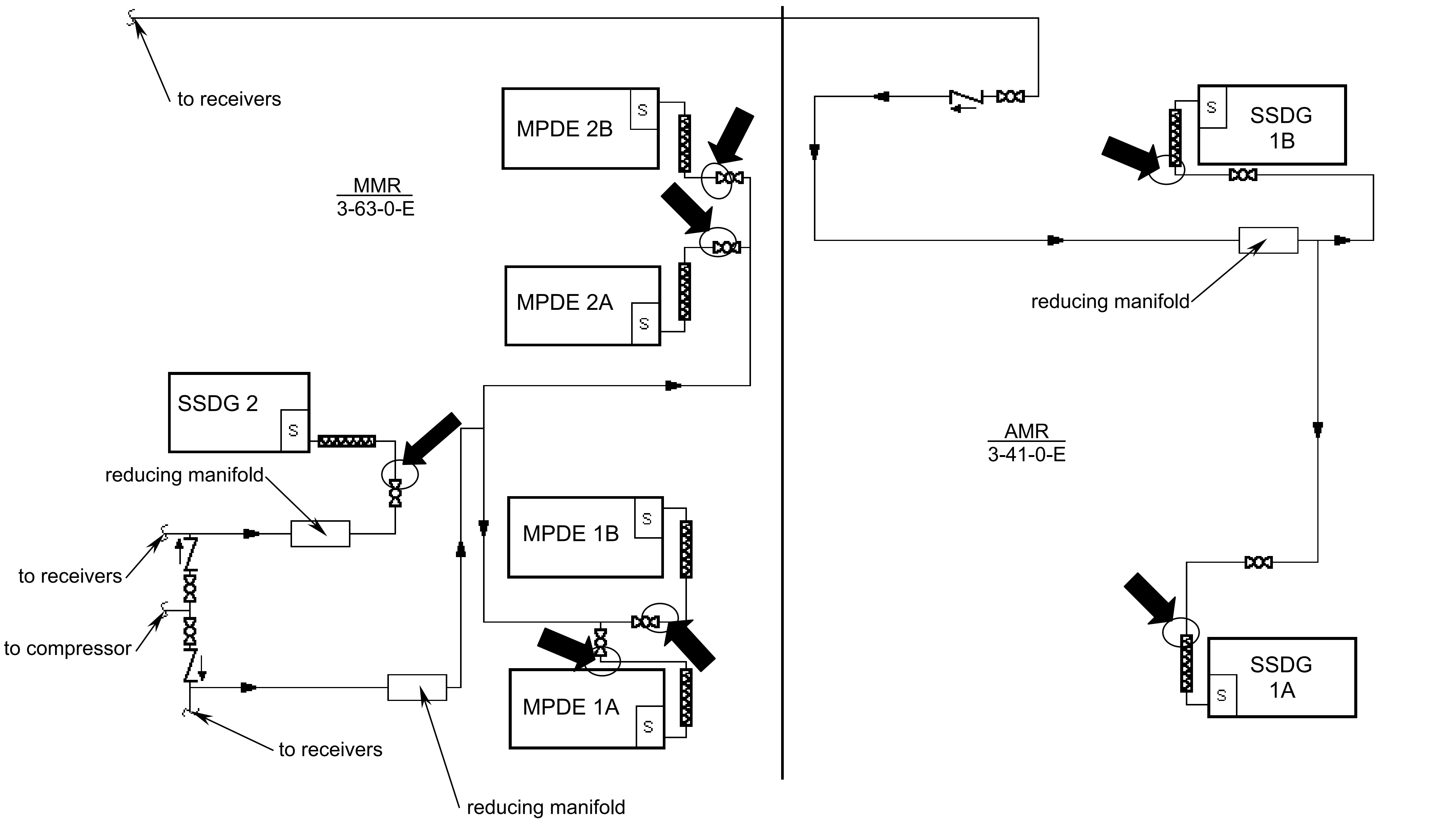

Figure 14
Compressed Air Boundary Diagram